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SCIENCE ABSTRACTS

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The List of Journals dealt with will be found at the commencement of each volume. The following are recent additions :—

"T.S.F." (Revue Mensuelle de Radiotelegraphie). "Die Antenne" (Zeitschrift für drahtlose Nachrichtübermittlung). "Verhandlungen des Vereins zur Beförderung des Gewerbfleisses."

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* Section "A" (Physics) contains abstracts from Papers on General Physics, Meteorology, Astronomy, Light, Heat, Sound, Electricity, Magnetism, Chemical Physics, &c.

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SCIENCE ABSTRACTS.

Section A.—PHYSICS.

OCTOBER 1914.

GENERAL PHYSICS.

1647. *Instrument for recording Pressure Variations due to Explosions in Tubes.* **J. D. Morgan.** (Phys. Soc., Proc. 26. pp. 172–177; Discussion, p. 177, April, 1914.)—A light steel vane of rectangular form is mounted parallel to the explosion tube in a cell presenting a lateral opening to the tube interior. Along three edges the vane is free, and along the fourth edge it is attached to a torsion wire. The vane, which is fitted with a dash-pot, is made to fit the cell as closely as possible around its edges without touching the sides of the cell. The diagram is produced by a style on a smoked paper strip wrapped around a clock-driven drum, and on the same strip is described a time curve by an electrically-driven tuning-fork of known frequency.

L. H. W.

1648. *Direct Measurement of the Napierian Base.* **R. Appleyard.** (Phys. Soc., Proc. 26. pp. 178–182; Discussion, p. 182, April, 1914.)—A description of a simple apparatus intended to convey to students an idea of the way in which the base e of the Napierian logarithms enters into physical problems in a specific case of wide application. A small length of chain is allowed to hang from a loop of thread, and the remaining part of the chain is then pulled aside until the thread is at 45° to the vertical. The curved portion becomes a true catenary when the angle between the vertical and curved portions of the chain at the attachment of the loop is 90°. To ensure that this condition is reached the circle of curvature of the catenary at that point is drawn, and this is found to have a radius equal to the vertical portion. In these circumstances, if the vertical length is taken as unity, and if its lower end is taken as origin, it is shown that e is the sum of the y-ordinate at $x = 1$, and the length of curved chain between the point where that y-ordinate cuts the curve and the top of the vertical portion. The application of this result to a simple representation of the relationship and meaning of hyperbolic functions is also shown, and it is urged that such functions should be studied from consideration of the catenary rather than from the hyperbola.

Author.

1649. *Gyrostatic Devices for the Control of Moving Bodies.* **J. G. Gray.** (Phys. Soc., Proc. 26. pp. 224–245; Discussion, pp. 246–247, June, 1914.)—The author describes a number of contrivances for stabilising and forcibly manœuvring moving bodies, such as torpedoes and airships. It is not possible to understand these properly without entering into details. All the models shown are provided with complete or real stability, the stabilising forces being derived from the propelling system. [See also Abstract No. 158 (1914).] L. H. W.

1650. *Reproduction and Measurement of very Short Intervals of Time.* **J. Coulson.** (Phys. Rev. 4. Ser. 2. pp. 40–46, July, 1914.)—It is often found desirable to have at one's disposal some means by which two neighbouring electric circuits can be broken in quick succession in such a way that the interval between these two operations is accurately predictable and under the control of the experimenter. This paper contains a brief description, with diagrams, of a simple apparatus which can be made to give time-intervals of very short duration. The apparatus is based on the principle that if a massive weight, falling freely under gravity, strikes a collar on a metal rod which is supported vertically, an elastic wave or impulse travels out along the rod in each direction from the collar with a finite velocity. If the impact takes place at the middle of the rod, these waves will, of course, reach the ends of the rod at the same time. If, however, the point at which the impact occurs be not at the middle of the rod, the impulses will reach the ends at times that differ by an interval which will depend on the path-differences. In this way controllable time intervals extending over a considerable range may be secured, and can easily be measured with the aid of proper apparatus. A. W.

1651. *Collapse of Tubes by External Pressure.* **R. V. Southwell.** (Phil. Mag. 26. pp. 502–511, Sept., 1913.)—Gives results of the experimental work referred to in Abstract No. 382 (1914). An investigation is made of the causes of some discrepancies which have been noticed between the resistance to collapse of actual tubes and the values given by the author's theoretical formula. Tubes exceeding the "critical length" (Carman) are alone considered. The results of Carman's experiments on seamless brass and steel tubes are compared with curves derived by the author's theory from the stress-strain diagrams of compression tests. It is concluded from a consideration of these curves that in employing in design formulæ which have been obtained from hydraulic testing apparatus serious over-estimates of strength are being made, unless the maintenance under practical conditions of the high elastic limit which is induced by the drawing process can be relied upon. L. H. W.

1652. *Collapse of Short Tubes by External Pressure.* **G. Cook.** (Phil. Mag. 28. pp. 51–56, July, 1914.)—Describes experiments on the collapse pressure of uniform solid-drawn steel tubes, 3 in. in internal diam., of various thicknesses and of lengths ranging from 2 to 12·7 in. Each tube was closed at both ends by thick cast-iron discs, and the cylinder thus formed was placed in a chamber where it could be subjected to an external pressure up to 3000 lbs. per sq. in. while the interior was kept in communication with the atmosphere. The collapsing pressure (p_1) was found for each tube and plotted (1) against the ratio of thickness to diam. (t/d), and (2) against the length (l). A separate curve is drawn in the first series for each different

value of l, and in the second series for each separate value of t/d. If p is the collapsing pressure of a tube of infinite length, but of the same diam. and thickness as the one under investigation, while L is the critical length, it is found from the second series of curves that the equation $p_1 = pL/l$ is more nearly satisfied by Southwell's value of $L(k\sqrt{d^3/t})$ than by Carman's (6*d*), but the tests are not sufficient in number, nor do they cover a wide enough range of dimensions to give definite confirmation of any theory. For these experiments the numerical value of the constant k would appear to be about 1·73 and the critical length L to vary from about 13 to 18 times the diam. [See also preceding Abstract.] J. W. T. W.

1653. *Influence of Time on the Rapid Deformation of Metals.* **G. Charpy** and **A. Cornu.** (Comptes Rendus, 158. pp. 1969–1972, June 29, 1914.)—Although the influence of time on the deformation of metals under slowly applied stresses is pretty well known, its influence in shock tests has not received much attention. The authors have endeavoured to fill this gap in our knowledge by a study of shock bending tests on notched and plain bars with the object of determining the effect of varying the height of fall, weight of the tup, and the rate of fracture on the resilience of the material. The results show that between the limits of 6 m. and 1 m. for the height of fall and a duration of deformation of between 1/1000 and 1/100 of a second the variation of the resilience is to all intents and purposes negligible, since it is well within the limits of experimental error. F. C. A. H. L.

1654. *Deformation of Rock-salt Crystals.* **T. Terada.** (Mathematico-Physical Soc., Tōkyō, Proc. 7. pp. 290–291, May, 1914.)—Describes an investigation, by means of a Röntgen-ray radiograph, of the molecular structure of a crystal of rock salt deformed while in the plastic state [see Abstract No. 1028 (1914).] A rock-salt plate was bent into a cylindrical form with one of the crystallographic axes along the generating line, and the results obtained are explainable on the assumption that the crystal, in bending, breaks up into several finite portions, each portion retaining its undeformed molecular lattice. The interspaces are probably filled up by minute crystals arranged as in the case of a fibrous substance. With a specimen pressed in boiling water between two cylindrical surfaces, it appears that the crystal is broken up into numerous small portions with irregular orientations. J. W. T. W.

1655. *Shape of Capillary Surface inside a Tube of Small Radius.* **A. Ferguson.** (Phil. Mag. 28. pp. 128–138, July, 1914.)—Formulæ are here obtained giving a closer approximation than usual to the outline of the surface of a liquid contained in a vertical tube of small bore. The formulæ are utilised in a discussion of the method used by Sentis for the determination of surface tensions. Applications are also made to Jaeger's method for surface-tension measurements and to a discussion of certain aspects of the experiments of Ramsay and Shields on the molecular complexity of liquids. [See also Abstract No. 344 (1913).] A. W.

1656. *Forces Acting on a Solid Sphere in Contact with a Liquid Surface.* II. **A. Ferguson.** (Phil. Mag. 28. pp. 149–153, July, 1914.)—Forms a continuation of a previous paper [see Abstract No. 181 (1914)] the methods of which it extends to cases in which the vertex of the sphere is not restricted to the level of the free liquid surface, but may be at any distance d_1 below it. From the results obtained the more rigid equation of equilibrium of a segment of a

sphere floating in a liquid may be at once deduced and gives the modification to be applied to the simple Archimedean equation in order to allow for surface tension. Further, the particular value of d_1 is found for which the upward force required to keep the sphere in equilibrium is just equal to its weight in air. A method of determining surface tension based on the use of this value of d_1 is considered by the author inferior in accuracy to the method originally adopted (*loc. cit.*). A simplified form of the experiment using a plate instead of a sphere is, however, described. The plate is first balanced in air. A vessel containing the liquid is then raised until the plate just touches its surface. The further motion, d_1, required to restore the plate to its original position of equilibrium gives the surface tension of the liquid. This forms an interesting extension of the ordinary detached-disc experiment. J. W. T. W.

1657. *Measurement of Air Velocities, Pressures, and Volumes.* **W. Cramp.** (Manchester Lit. and Phil. Soc., Mem. 58. 7. pp. 1–16, June, 1914.)—For various reasons the anemometer is unsatisfactory in measuring air velocities; it is rather an indicator. The Pitot tube is accurate provided the facing tube is small and of such a form that stream-line flow is not much disturbed. Various tubes are compared; the Nipher collector is very inaccurate, and the Brabbée tube seems superior to anything but the Standard Pitot with static tube in pipe wall. This latter involves holes with good internal surfaces to be drilled at various points and is in commercial work often impossible. The Brabée tube seems very little affected by faulty setting. In determining the volume of air passing through a pipe, the author takes the central velocity x a coefficient to give the mean velocity. For central velocities of 6·89, 7·72, 8·53, 9·16, 9·42 m. per sec. the coefficient is 0·8, 0·9, 0·9, 0·9, 0·88 respectively. With water flow the author remarks that the coefficient is about 0·85. The Krell-Prandtl pneumometer is also described. H. S. R.

1658. *Application of W. Ritz's Method to the Problem of Uniform Flow in a Square Tube.* **M. Paschoud.** (Comptes Rendus, 159. pp. 158–160, July 13, 1914.)—J. Boussinesq treated this problem by the approximate method of Saint-Venant. The author shows how the method which was used by Ritz in discussing the equilibrium of thin elastic plates, may be applied to the problem of flow. J. Boussinesq observes in an appended note the essence of Ritz's method to be the use of a double instead of a single series with the advantage that it automatically breaks up the differential equation into easily integrable components. H. S. R.

1659. *A Hydrodynamic Experiment.* **D. Riabouchinsky.** (Boll. dell' Aero Club di Roma, 9. 1. p. 7, March, 1914. Amer. Soc. Mech. Engin., Journ. 36. p. 0122, June, 1914. Abstract.)—The phenomenon of the rotation of a rectangular plate in an air current can only be repeated in water if sufficient inertia is provided. C. A. B.

1660. *Possible Dependence of Gravitational Attraction on Chemical Composition, and Fluctuations of the Moon's Longitude which might result therefrom.* **C. V. Burton.** (Phil. Mag. 26. pp. 252–256, Aug., 1914.)—The author first refers briefly to the pendulum work of Newton and Bessel on the degree of accuracy to which the Newtonian coefficient of gravitation is a universal constant of matter independent of chemical and physical properties. He then points out that the planets of the solar system, which may be supposed to differ in composition since their mean densities are so various, should by the exactitude with which their orbits conform to Kepler's third law

be evidence of the close uniformity of the Newtonian coefficient. The earth-moon system would most readily exhibit any departure from strict uniformity, and the author shows by a mathematical discussion that if the gravitational indices for earth and moon differ by but one part in 20,000,000, the fluctuations of the moon's longitude would comprise a term of period one lunar month and amplitude one second of arc. Hence it follows that the earth and her satellite, widely as they differ in mean density, must have, within one part in many millions, the same gravitational index. The author thinks it should be possible to speak more definitely when the short-period terms in the moon's longitude have been adequately discussed. H. H. Ho.

1661. *The Specification of the Elements of Stress.* **R. F. Gwyther.** (Manchester Lit. and Phil. Soc., Mem. 58. 5. pp. 1–21, June, 1914.)—A further contribution [see Abstract No. 1628 (1912)].

1662. *"Suction" between passing Ships.* **S. A. Reeve.** (Engineering, 98. pp. 195–198, Aug. 7; 228–231, Aug. 14, and pp. 243–245, Aug. 21, 1914.)—Deals with the subject under the following headings: History and general Theory; Ship waves and sea-contours; Interaction between two or more ships; Actual instances of suction collision. L. H. W.

1663. *Equilibrium of Revolving Liquid under Capillary Force.* **Rayleigh.** (Phil. Mag. 28. pp. 161–170, Aug., 1914.)—Deals with the case where the revolving mass assumes the form of a *thin* ring. L. H. W.

1664. *Stability of Bohr's Model Atom.* **L. Föppl.** (Phys. Zeitschr. 15. pp. 707–712, July 15, 1914.)—Mathematical.

1665. *American Temperatures and European Rainfall.* **W. J. Humphreys.** (Washington Acad. Sci., Journ. 4. pp. 345–347, June 19, 1914.)—The author has previously established that the average temperature of the earth is closely related to the sun-spot cycle, and also to the amount of volcanic dust in the high atmosphere [see Abstract No. 1586 (1913)]. It would seem, then, that many other meteorological elements must also vary according to the same period as that found in the temperature. A preliminary attempt is here described which seeks a connection between the temperature of the Eastern United States and the rainfall of Germany. A close connection is found over the period of years investigated, 1874–1913. It is pointed out that this is only what would be expected, since the prevailing wind blows from west to east across the Atlantic, and warm weather over the Eastern States of America would naturally be associated with increased evaporation in that district and greater water-contents in the air. J. S. Di.

1666. *Climate of Eastern Siberia.* **A. W. Wosnessensky** and **A. B. Schostakowicz.** ([483 pp.], Irkutsk, 1913. Review by A. Woeikof in Meteorolog. Zeitschr. 31. pp. 161–169, April, 1914.)—In the review figures are given which show the remarkable difference between the high summer temperatures in Eastern Siberia and those found in Central Europe for the same latitude and height above sea-level. This heat is very advantageous for agricultural purposes, but is offset to some extent by the fact that though the variation of the monthly means is small for the seven stations dealt with, the absolute variation is very large. Attention is also called to the frequency with which winter temperatures of −60° C. are observed in North-eastern Siberia. L. H. W

1667. *Seiches of Lake Towada.* (Sci. Reports, Tôhoku Univ., Sendai, 2. No. 4. pp. 163–169, 1913.)—This is one of the deepest lakes in Japan, and of great transparency. Three sets of Honda's limnimeters were used, and simultaneous observations made at different stations. The different modes of free oscillations were studied by means of a model of the lake, the surface of the water being covered with aluminium powder which admitted of photographs being taken of the freely oscillating water; six of these are included. By comparing the above modes of oscillation with those actually observed, it was found that the largest observed period, 17·33 mins., was that of the fundamental oscillation of the lake. The various data are graphically given by twelve diagrams. H. H. Ho.

1668. *Distribution of Prominences on the Sun's Suiface.* **A. Riccò.** (Accad. Lincei, Atti, 22. pp. 525–532, Dec. 7, 1913.)—Observations which have been conducted during three 11-year cycles have yielded no regular and precise results as regards the distribution of sun-spots, but nevertheless certain reliable conclusions can be drawn from the 33 years' consistent observations. These conclusions are summarised by the author as follows:—(1) In both solar hemispheres there is a zone of maximum prominence frequency at 20° to 40° of heliographic latitude, and this persists throughout the whole 11-year cycle, except near the epoch of minimum solar activity, when it is absent. (2) There is another region of max. prominence frequency which commences to become manifest about the time of the 11-year maximum, lying between 40° and 60°, and lasts till about the time of the 11-year minimum, then transports itself to higher latitudes, as far as the polar regions of the sun at the epoch of the maximum. (3) After the epoch of reduced activity, there is only a single zone (the lowest) of prominence frequency; at the time of greater activity there are two. (4) In the first zone the prominences formed are eruptive and metallic; in the other regions only quiescent, hydrogeneous prominences are formed. (5) The distribution and change in latitude of the maxima during the 11-year cycle of prominences are entirely different from those of the sun-spots. (6) In each of the three cycles of the Sicilian observations the northern prominences were, in general, less frequent than the southern. In the preceding cycle, on the other hand, the northern were more prevalent than the southern. (7) The mean heliographic latitudes of the prominences were higher near the time of minimum activity, and lower at that of the maxima. (8) The mean latitudes of prominences, north as well as south, of each cycle differed little from one another and show a mean value of $34\frac{1}{2}°$. (9) The mean annual latitudes of all the prominences, both north and south, have oscillated between $+3°$ and $-7°$; generally the negative values prevail near minimum activity, and positive near maximum activity. (10) The mean latitudes of all the prominences, taking both hemispheres together, in the three cycles, were all three positive and less than 1°. L. H. W.

LIGHT.

1669. *Cyanometer.* **G. A. Tichov [Tikhoff].** (Acad. Sci. St. Pétersbourg, Bull. 11. pp. 809–813, June 15, 1914.)—In this preliminary note the author outlines the construction of a cyanometer by means of which a blue light may be produced with the intensities of its components, like those of the normal blue of the sky, in inverse proportion to the fourth power of their wave-lengths. T. H. P.

1670. *Intermittent Vision.* **S. P. Thompson.** (Roy. Soc., Proc. Ser. A. 90. pp. 448–449, July 20, 1914.)—In a previous paper [Abstract No. 648 (1914)] Mallock, in order to account for the intermittences seen when watching a revolving disc of black and white sectors, at the moment when a slight mechanical shock is given to the head or body, advanced the hypothesis that a slight mechanical shock produces a periodic but rapidly extinguished paralysis of the perception of light, and that the nerves on which seeing depends cannot bear more than a certain amount of mechanical acceleration without loss of sensibility.

This hypothesis of a momentary paralysis of the sense of vision seems to be unnecessary. The sector disc revolving at from 2 to 6 revolutions per sec. presents a uniform grey tint. On stamping the foot or tapping the head, the most prominent effect observed by the present author was not the momentary appearance of stationary grey or black sectors, but the enhanced brightness of stationary white sectors. A momentary paralysis, if it occurred, should produce momentary blackness of the entire disc, which is not what happens. To further test the phenomenon, a revolving sector disc, driven uniformly by a small motor, was arranged so that it could be observed either directly from a distance of a few feet or by reflection in a small mirror. When a slight shock is given to the mirror so as to alter by a small amount the apparent position of the revolving disc, an intermittence is produced of the same kind as is observed when a shock is given to the head or body. The sectors appear momentarily to stand still, and the brightness of the white sectors is for an instant enhanced. The explanation of the effect appears to be that when the moving images of the white sectors on the retina are suddenly shifted by a minute displacement, they fall on some of the rods and cones which are relatively unfatigued, and which, for the instant, are therefore of greater sensitiveness. A. W.

1671. *Axial Chromatic Aberration of the Human Eye.* **P. G. Nutting.** (Roy. Soc., Proc. Ser. A. 90. pp. 440–443, July 20, 1914. Washington Acad. Sci., Journ. 4. pp. 385–388, Aug., 1914.)—A bright object viewed directly by a normal human eye shows no perceptible coloured fringes. If the same object be viewed through a filter transmitting only the extreme red and blue, it will appear with either a blue or red fringe, showing that for these extreme rays the eye is not corrected. Helmholtz passed monochromatic light through a small hole, and found that with red light the hole appeared in best focus when viewed from a distance of about 8 ft., with blue light at about 1½ ft., and with extreme violet at a few inches. With these rough determinations the question appears to have rested. A method is here described of obtaining rather precise determinations of axial focal length by means of very simple

apparatus. The monochromatic rays of a Nernst, or a mercury, lamp, pass through a slit, and then through a movable lens of 20 cm. focal length, to the eye. The image of the slit formed by the lens serves as test object. In order to fix the accommodation a glass plate at 45° is placed between eye and lens, reflecting the image of a side object at the desired distance. Three eyes were tested at accommodations for 25 cm., 100 cm., and infinity; the others for infinity only. The side object should be dark, a black letter, or distant tree-trunk for instance, so that the slit may appear against a dark background. A shift of the lens 1 cm. corresponds to 0·01 mm. shift in focal point at the retina. The results for seven observers are shown in tables and curves, the axial error curve for "an eye of pure water" being also given for comparison. In the most luminous part of the spectrum, from 520 to 660, all the eyes tested show less variation in focus than an equivalent eye of pure water would have. In some eyes the correction in the central region would compare favourably with that of a good photographic or telescopic objective. Several types of correction are shown that are new to lens optics. In two cases high-order central corrections are accompanied by decreased violet but normal red correction. One case shows no correction except in the extreme red and violet, where the correction is normal. Another is slightly corrected except in the extreme regions. Another is fairly well corrected over a wide region, from 480 to 780. Some tests were made for residual chromatic spherical aberration (departure from Gauss condition) by placing half of a half-tone screen over the test slit. The author could detect no residual in his own eye from 500 to 650, but beyond 700 in the red and 480 in the blue it was noticeable, while at 406 in the violet it amounted to 20 times the normal diffusion. One observer agreed with the author, while another could detect little loss of definition at 406. A. E.

1672. *Simple Unit Method for measuring the Actinic Effect of Illuminants in the Practice of Photography.* **F. M. Steadman.** (Amer. Illum. Engin. Soc., Trans. 9. pp. 265–289; Discussion, pp. 289–291, March, 1914.)—The treatise of which the present paper is a brief abstract, was written in the hope of establishing a rational scientific foundation for the practice of photography and for the study of light as it is daily observed in Nature. It is shown that the chemical energy of light, the relative aperture of a lens, the degree of sensitiveness of photographic emulsions, which are the fundamental elements in photography, are at present lacking simple units of measurement. The whole system has been named "Aabacraft Photography." A term "actinism" is used, and defined to denote the chemical property of radiation, and a unit of it under specified conditions is called an "actino." A practical actinometer is described and its use explained. A unit cone system for the measurement of light convergence is developed, and the relation of such a system to the systems of lens stops, now in use, is explained; also the Hurter and Driffield work in their analysis of what may be called a "perfect printing negative" is developed. The theory of the "characteristic curve" of a given photographic plate and the "law of constant density ratios" are gone into with considerable detail. The paper also includes a number of problems illustrating the important points considered. A. E. G.

1673. *Dynamical Theory of Diffraction.* **D. N. Mallik.** (Phil. Mag. 28. pp. 224–233, Aug., 1914.)—Mathematical.

1674. *A Graphic Treatment of Cusped Wave-fronts and of the Rainbow.* **W. R. Bower.** (Phys. Soc., Proc. 26. pp. 212–222; Communications,

pp. 222–223, June, 1914.)—A method of drawing the cusped wave-fronts produced by refraction and reflection at a spherical surface and a graphic treatment of the elementary theory of the rainbow are described. The method is based upon the properties of the centre of junction. L. H. W.

1675. *On Anomalous Trichromatic Colour Vision.* **W. Watson.** (Roy. Soc., Proc. Ser. A. 90. pp. 443–448, July 20, 1914.)

1676. *Absorption and Refraction Indices for Thin Copper.* **W. Planck.** (Phys. Zeitschr. 15. pp. 563–568, June 1, 1914.)—Describes experiments on the absorption and refraction of layers of thin copper. The method adopted was similar to that used by Galli [Dissertation, Göttingen, 1913]. The chief interest of the paper lies in the tables and diagrams of the results. Theory is also given. A. W.

1677. *Damping of Oscillations in Luminous Vapours.* **R. Ladenburg.** (Phys. Zeitschr. 15. pp. 690–694, July 15, 1914.)—A paper discussing the method of Mandelstam and v. Ubisch [see Abstract No. 1478 (1911)] for the damping of the oscillations in luminous vapours. It appears that the method gives a value for the luminous Na-vapour about ten times as great as that found by Ladenburg and Senftleben by a method to be fully described later. A discussion of the theory of the researches of Mandelstam and v. Ubisch shows that the equations used by v. Ubisch for the calculation of the damping coefficient only hold for very rare vapours. The dependence of the absorption coefficient (and hence the intensity distribution of the sodium lines) on the frequency is also dealt with. Further, from the researches of Voigt and of Ladenburg and Reiche [see Abstract No. 1529 (1914)] it appears that the function deduced by Rayleigh from the Doppler-effect is more important for the intensity distribution of the lines investigated as the vapour becomes less dense. Consequently these lines, for small vapour densities, are characterised not so much by the damping of the oscillations as by the velocity of the luminous centres or carriers, and in this case researches on the lines of the method of Mandelstam and v. Ubisch allow this velocity to be calculated. The necessary equations for this are given. A. W.

1678. *Relation between the Emission Spectrum of a Compound and its Absorption Spectrum in Solution.* **A. K. Chapman.** (Phys. Rev. 4. Ser. 2. pp. 28–30, July, 1914.)—Spectrometric investigation of mercuric iodide, stannic iodide, ferrous iodide, and mercurous chloride, which are characterised by a wide emission band shading off towards both the red and the violet, indicates the existence of a definite relation between the absorption and emission bands, and it would seem that the vibrating system responsible for the emission is also effective in producing absorption in solution. T. H. P.

1679. *Absorption Spectra at very Low Temperatures.* **A. Mazzucchelli.** (Accad. Lincei, Atti, 23. pp. 953–959, June 21, 1914.)—In view of the fact that the bands of the phosphorescence spectra of uranyl salts become narrower and more clearly defined at very low temperatures, the author has investigated the absorption spectra of various uranyl salts at temperatures somewhat above —180°. At such temperatures solutions of the salts in ethyl alcohol solidify to transparent, glassy masses, which were used for observation ; addition of glycerol or of methyl alcohol to the ethyl alcohol lowers the solidifying point considerably, but the resultant glassy masses then either disintegrate rapidly or are opaque. The absorption bands are found to become clearer and to be

displaced appreciably at the low temperatures employed; in some cases new bands make their appearance. Examination of various colouring matters in the same manner shows that at about —180° the absorption bands differ but very slightly in position and clearness from those observed at ordinary temperatures. It seems, therefore, that the influence of low temperatures on the absorption bands is pronounced only with those compounds, the selective absorption of which is a property of one of the constituent elements. T. H. P.

1680. *Series Lines in Spark Spectra.* **A. Fowler.** (Roy. Soc., Phil. Trans. 214. pp. 225-266, July 18, 1914. Roy. Soc., Proc. Ser. A. 90. pp. 426–430, July 20, 1914.)—The work of Rydburg, and that of Kayser and Runge, dealt mainly with series lines in spectra which are developed in the flame or electric arc, or in vacuum tubes with discharges of moderate intensity. The lines to be discussed in the present communication are some of those which belong to the class of "enhanced" lines as defined by Lockyer; that is, they are relatively intensified in passing from arc to spark conditions. In considering these lines it is necessary to take account of the fact that their behaviour in the arc is different for different elements. At least three classes may be recognised: (1) Enhanced lines like the H and K lines of calcium, which are well developed in the ordinary arc. (2) Lines which only appear with small intensities in the arc, such as the enhanced lines of iron. (3) Lines which do not appear in the ordinary arc (except very locally near the poles), but are strongly developed under spark conditions, as in the case of the well-known magnesium line at λ4481. Until very recently the only evidence that enhanced lines may belong to series was that afforded by Runge and Paschen's observations of the spectra of Mg, Ca, Sr, Ba, and Ra, under the influence of a magnetic field. In the case of each of these elements three pairs of lines of class 1 were observed, and though no series formulæ could be calculated for them, the magnetic resolutions proved that one pair belonged to the Principal series, another to the Sharp, and the third to the Diffuse series. Further discussion of these series has become possible through the work of Lyman in the Schumann region.

The present investigation was undertaken in connection with the new series of lines which were produced in 1912 by passing strong condensed discharges through helium tubes containing hydrogen as an impurity. These lines, of which the strongest is at λ4686, are of considerable importance in celestial spectroscopy because of their occurrence in the spectra of some of the nebulae, and in stars which are generally regarded as representing the earliest stages of stellar condensation. One of the series, only feebly visible, was in apparent agreement with a series of lines first observed in ζ Puppis by Pickering, and attributed to hydrogen because of their simple relation to the Balmer hydrogen series. The other was a strong series, which included the lines assigned by Rydberg to the Principal series of hydrogen from analogy with the spectra of the alkali metals. In addition to the Rydberg lines, however, the "4686" series included intermediate lines which the then recognised formulæ suggested was a second Principal series related in a simple manner to the first. As the new lines could not be obtained from hydrogen alone, and in consideration of the occurrence of lines not anticipated by Rydberg, it was soon felt that further inquiry should be made as to the value of the numerical evidence on which their assignment to hydrogen was chiefly founded. A search for other series of similar character was therefore undertaken, in the hope that some generalisation with regard to such series might be arrived at. The mode of production of the "4686" lines suggested

spark spectra as the most promising source of such series, and, shortly afterwards, experiments on magnesium yielded some new lines of that element which were obviously associated with the spark line 4481 in series of the kind looked for. No satisfactory evidence of relation to other series of Mg lines, however, was then obtained, and it seemed possible that both the "4686" and the "4481" series were of a new type, having no necessarily simple relation to other known series in the respective spectra.

The lines of the "4686" and the associated Pickering series have since become of increased importance, in connection with theories of the constitution of the atom, through the theoretical investigations of Bohr. Beginning with the "Rutherford" model of the atom, and introducing Planck's quantum, Bohr has derived a formula for the hydrogen spectrum which excludes these lines, while agreeing closely with the hydrogen series about which there can be no doubt. The "4686" and Pickering series, however, are included in another formula, derived for the emission of He-atoms during the first stage of their re-formation when both electrons are supposed to have been removed by the strong discharges employed. This formula is identical, in a first approximation, with that for hydrogen except that the Rydberg constant "N" (= 109,675 for Rowland's scale) has four times its ordinary value. The two "Principal" series previously assigned to hydrogen were thus united in a single formula attributed to helium, while the Pickering series was made to include intermediate lines coincident with the Balmer series of hydrogen. As the lines in question, whatever their origin, must be regarded as enhanced lines, it was evidently desirable to continue the general investigation of lines of this class. Further investigation of magnesium, in particular, was also suggested by the discovery made by Paschen, and by King, that the line 4481 is a close doublet, as it appeared that a valuable indication of the type of series to which it belongs might be obtained if other members could be resolved. Photographs with high dispersion have accordingly been taken for the resolution of the lines and to provide more accurate data for testing the formula for enhanced lines which was suggested by the work of Bohr. Other photographs, taken with smaller dispersion, have resulted in the detection of additional lines which clearly belong to series related to that beginning with 4481.

The discussion of the new data for Ca and Sr given by other observers, has led to some conclusions which are probably of general application to enhanced line series. The chief results of the investigation are as follows :—The enhanced (spark) lines of Mg, Ca, Sr, and Ba form series of doublets which occur in groups similar to those previously recognised in arc spectra. The formulæ representing these series, however, differ from those employed for arc lines in that Rydberg's constant "N" (= 109,675 for Rowland's scale) has a value equal to 4N. The Fundamental series, in the doublet systems of Ca, Sr, and Ba as shown by Saunders and Lorenser, derives its limit and the separation of its components from an observed negative form of the Diffuse series, and the Fundamental series, which might have been expected, do not exist. A new group of series of narrower doublets has been found in Mg, in which the separation of the Sharp and Diffuse pairs is identical with the (calculated) separation of the second pair of the Principal series of wider doublets. The new group is designated the "F.P." system : in addition to the ordinary series it includes two well-marked combination series, each consisting of seven observed lines. The "4481" series of Mg consists of very close doublets with constant separation, and forms the Fundamental series of the F.P. system. Its limits

are derived from the first negative term of the Diffuse series. Corresponding series of the F.P. and Wide doublet systems run parallel to each other, but notwithstanding this numerical relation, the two systems do not necessarily co-exist, the wider doublets occurring in the ordinary arc as well as in the spark, while the F.P. group occurs only under spark conditions or their equivalent in the region of the negative pole of an arc *in vacuo*. No numerical relations have been traced between any of the enhanced line series of arc lines of the same element. The "4686" series produced in helium tubes is of the enhanced line (4N) type, and can no longer be considered to belong to the same group as the Balmer series of hydrogen, which is of the arc (N) type. It is concluded that these lines are due to He as indicated by Bohr from theoretical considerations; it is suggested that they should be designated "proto-helium" lines. Analogy with the "4481" series of Mg indicates that the "4686" series of proto-helium is primarily of the Fundamental type: the three associated series may be regarded as coincident with it. The Pickering lines associated with the "4686" series are also probably due to proto-helium, in which case the series would include lines nearly coincident with the Balmer series. The observational evidence on this point is incomplete, but the assignment of these lines to proto-helium is supported by the fact that one of the new combination series of magnesium is related to the "4481" series exactly as the extended Pickering series would be related to the "4686" series. The slight differences between the observed positions of alternate lines of the "4686" series and those calculated by Rydberg for the Principal series of hydrogen are in very close agreement with Bohr's theoretical formulæ for hydrogen and proto-helium. Adopting these formulæ, the spectroscopic data give a provisional value for the mass of the hydrogen atom, in terms of that of the electron, as 1836 ± 12 or 1855 ± 12 when the data are corrected to the International scale of wave-lengths. The appearance of the Rydberg constant in enhanced line series with four times its usual value may be explained on Bohr's theory by supposing that series of the arc type are produced when only one electron is removed from each of the atoms involved, while in the case of enhanced lines two electrons are removed. A preliminary examination of terrestrial and celestial spectra has given no indications of series requiring still greater multiples of the Rydberg constant in the formulæ representing them.

In an appendix the wave-lengths (on the International scale) of the enhanced lines of magnesium, as observed in the arc *in vacuo* in the course of the foregoing investigation, are brought together in a Table. For completeness additional lines observed by Lorenser and by Lyman are also included.

A. E. G.

1681. *Spectra given by Carbon and some of its Compounds.* **W. M. Watts.** (Phil. Mag. 28. pp. 117–128, July, 1914.)—A discussion is first given of previous work relating more particularly to the origin of the "Swan" spectrum. Experiments are then described in which the Swan spectrum was observed in the absence of oxygen, so far as it is possible to secure that condition. Observations with either the arc or spark in specially pure liquids showed that the Swan spectrum was produced in all the liquids used: heptane, hexane, octane, carbon tetrachloride, and chlorobenzene. On account of the rapid separation of carbon, only a few seconds were available for observation, and, consequently photographs could not be obtained. A summary is given of wave-length measurements of the chief lines of the band-spectra of carbon and some of its compounds. The results of the experiments, taken in conjunction

with those obtained by other investigators, lead to the conclusion that the Swan spectrum is due to carbon-vapour only. A study of Thomson's results shows that the Swan spectrum is given by the negatively-charged carbon atom, and not by either CO or CO_2. The Swan spectrum is given by CO at atmospheric pressure, but not by CO_2. In CO as the pressure is reduced the Swan spectrum dies away, and at low pressures is completely replaced by the second spectrum. This indicates that CO contains something not present in CO_2, but that this something gets smaller in amount as the pressure is reduced. Now Thomson finds that both carbon monoxide and carbon dioxide contain C++, O++, C+, O+, CO_2+, and CO+, whereas carbon monoxide alone contains C—. Further, he shows that such negatively charged atoms ought to be, and are, less numerous when the discharge has difficulty in passing, *i.e.* at low pressures. A. W.

1682. *Zeeman-effect of Neon Lines.* **T. Takamine** and **K. Yamada.** (Mathematico-Physical Soc., Tōkyō, Proc. 7. pp. 277–290, May, 1914.)—In these experiments absolute determinations of the strength of the magnetic fields were not attempted, but the separations of the lines under investigation were compared with the separation of a standard line of which the amount of separation is known for given field strengths. For such a spectrum as that of neon, which has a large number of bright lines in a comparatively narrow region between the yellow and red, it is convenient to use a horizontal echelon, as employed by Zeeman in his study of the dissymmetry of the Zeeman-effect of the Hg line λ5790. But the use of a Fabry-Perot interferometer is desirable on account of the smallness of the probable errors in the result. Applying both methods, two photographs were taken simultaneously for each stage of the strength of the magnetic field. The experiments were confined to the transverse Zeeman-effect. The separation of 28 neon lines was investigated for field strengths up to about 18,000 gauss. Most of the results agree with the previous work of Lohmann [Abstract No. 247 (1907)], but for some lines the results were not in good agreement, necessitating a change of the types assigned by Runge. Besides the lines investigated by Lohmann seven new lines were photographed and measured; these are given below :—

λ.	Separation.	Type.	λ.	Separation.	Type.
7032·65	9	*a*/2	5689·96	9	*a*/2
6929·78	9	*a*/10	5562·90	3	*a*/8
5820·29	3	*a*	5330·90	9	*a*/6
5764·55	3	*a*/8			

The regularity in the constant frequency-difference between many red lines is accompanied at the same time by regularity in the separations and intensity distributions of the magnetically separated lines. A. W.

1683. *Radiation of Gas Molecules excited by Light.* **R. W. Wood.** (Phys. Soc., Proc. 26. pp. 185–211, June, 1914. First Guthrie Lecture, delivered Feb. 27, 1914.)—Deals generally with the subject of resonance radiation, briefly summarising the results of the lecturer's recent work. L. H. W.

1684. *Luminescence of Kunzite.* **E. L. Nichols** and **H. L. Howes.** (Phys. Rev. 4. Ser. 2. pp. 18-27, July, 1914.)—The authors have investigated the fluorescence, absorption, and phosphorescence of two samples of kunzite,

one in pink or rose-lilac crystals and the other in crystals almost colourless but with a suspicion of green or aquamarine tint [see Pochettino, Abstracts Nos. 375 (1910), 881 (1911)]. The red fluorescence band lying between 0·7 μ and 0·5 μ has a curve of distribution of intensities almost symmetrical about a crest at 0·59 μ, but somewhat steeper towards the violet. The blue fluorescence band lies between 0·49 μ and 0·40 μ, with a crest at approximately 0·432 μ. When the red bands of the two varieties, under kathodic excitation, are equally bright, the blue band of the white kunzite is 2·33 times as intense as that of the pink form. The absorption bands were also measured. The phosphorescence of kunzite exhibits various peculiarities. While it is of comparatively long duration, being easily discernible for several minutes after adequate excitation, decay is at first of extraordinary rapidity, so that measurable brightness remains only in cases where the initial intensity of excitation is very great; the law of decay was studied. Unlike many other phosphorescent substances, kunzite is comparatively inactive to photo-excitation, possibly owing to its transparency even in the absorption band. Like most, if not all, substances with protracted phosphorescence, kunzite requires an appreciable time to reach its maximum of excitation; under kathodic bombardment saturation is attained after a few seconds.

The investigator did not take into account the important feature of polarisation. T. H. P.

1685. *Luminescence.* **E. H. Farnau.** (Le Radium, 2. pp. 168–176, June, 1914.)—Observations on the luminescence produced in certain salts by various agents have been made. The results obtained together with those of other observers are tabulated, and certain conclusions drawn from them as to the origin of the luminescence [see Abstract No. 473 (1914)]. In the author's observations colour photography was made use of to record the quality of the luminescence. Observations were also made on the change of colour of a number of substances when compressed. This change of colour was shown, in certain cases at least, to be due to simple agglomeration and not to the formation of allotropic modifications. F. J. H.

1686. *End Product of Thorium Family.* **R. W. Lawson.** (Nature, 93. p. 479, July 9, 1914.)—Recent conclusions appear to show that the end products of all the radio-active families ought to be isotopic, or chemically identical, with lead. While there is good evidence for this in the case of the uranium family there is little in the case of thorium. From an investigation of the lead-content of several thorites and orangites, rich in Th, the author deduces that the end product of the known thorium family, viz. ThE, must be unstable with a period about 6×10^5 years. E. M.

1687. *Radio-activity and Atomic Numbers.* **A van den Broek.** (Nature, 93. p. 480, July 9, 1914.)—Let Th_T, Ra_T, Ac_T be the periods of half change of corresponding members of the thorium, radium, and actinium family respectively, M the atomic number, M(Pb) that of lead (and its isotopes) and c a constant ($\pm 4{\cdot}5$); then for all substances emitting α-rays the following empirical relation is shown to hold approximately: $Th_T = \sqrt{Ra_T \cdot Ac_T / c^{[M-M(Pb)]}}$. E. M.

1688. *Radio-activity of Rocks of the Kolar Goldfields.* **H. E. Watson** and **G. Pal.** (Phil. Mag. 28. pp. 44–51, July, 1914.)—The distribution of radium in five of the great mines is uniform, the amount of Ra per gm. of rock ranging from 14 to 34, in units of 10^{-14} gm. The quantity of Ra does not vary greatly with the Au-content. L. H. W.

HEAT.

1689. *Specific Heats of Liquids at Various Constant Pressures and Various Temperatures.* II. **S. Lussana.** (N. Cimento, 7. Ser. 6. pp. 304–312, May, 1914.)—Further measurements on ether at higher temperatures than those previously employed [see Abstract No. 89 (1913)] show that, as with ethyl and amyl alcohols, the diminution of c_p as the pressure rises, tends to become lower at the higher temperatures and pressures; at a sufficiently high pressure the variation of c_p changes its sign. The value of $c_p : c_v$, or γ, diminishes as the temperature and pressure rise. If the external work effected in liquids during heating be neglected and the difference between the two specific heats be attributed solely to the internal work, these results, in conjunction with the variations of the coefficient of dilatation at constant pressure with the pressure and temperature would show that the amount of internal work necessary during heating diminishes with increase of the pressure. The conclusion is drawn that the diminution of the distance between the molecules of liquids, which is naturally accompanied by restriction of the liberty of movement of the molecules, carries with it a diminution in the value of γ, and hence tends to cause the heat consumed during heating to aid the molecular energy. T. H. P.

1690. *Ratio of the Specific Heats of Gases.* **H. N. Mercer.** (Phys. Soc., Proc. 26. pp. 155–163; Discussion, p. 164, April, 1914.)—The main object of the experiments was to test the accuracy with which the ratio of the specific heats could be measured, using small quantities of the gas, with the ultimate view of experiments on the variation of the ratio with temperature. The method employed was that of Lummer and Pringsheim, in which the instantaneous fall of temperature corresponding to a given rapid fall of pressure is observed with a Pt thermometer of very fine wire. The values of the specific heat at constant pressure, calculated from the experiments, for air, hydrogen, carbon dioxide, and nitrous oxide are respectively 0·2403, 3·4704, 0·2000, 0·2185. These are in good agreement with direct calorimetric determinations. J. J. S.

1691. *Specific Heats and Principle of Similitude.* **R. C. Tolman.** (Phys. Rev. 4. Ser. 2. pp. 145–153, Aug., 1914.)—The author has already presented a number of derivations in different fields of physical science, all based on a single postulate called the principle of similitude, viz. "The fundamental entities of which the physical universe is constructed are of such a nature that from them a miniature universe could be constructed exactly similar in every respect to the present universe." In the present paper this same principle is used in deriving a formula for the specific heat of homogeneous isotropic elastic substances. It is found that the formula thus obtained for specific heat agrees with that of Debye for the specific heat of solids and liquids at low temperatures. But in the proof here given, it is *not* necessary to make use of any of the various forms of quantum theory. [See Abstracts Nos. 446 (1913) and 1195 (1914).] E. H. B.

1692. *The Lost Pressure in Gaseous Explosions.* **W. M. Thornton.** (Phil. Mag. 28. pp. 18–29, July, 1914.)—The total action in a gaseous explo-

sion is a multiple of that occurring in the formation of a single molecule. Consideration of the case of a diatomic gas gives the value 0·5 for the ratio of translational energies before and after formation. Experiment shows that this ratio varies in a definite manner and that the mean of its values over the working range in coal-gas and in many other mixtures giving perfect combustion also approaches 0·5. The suggestion is made that the "suppressed heat" in gaseous explosions may be explained by the influence of forces of cohesion which come into action at the moment of "contact" of two combining atoms. It would explain: (1) the loss of pressure; (2) the variation of the efficiency of combustion with strength of mixture; (3) the shape of the maximum pressure-percentage curves; (4) the differences between the explosion efficiency of gases having different limits of inflammability; (5) the influence of initial compression in raising efficiency of explosion, as a consequence of the limiting shape of the efficiency curves. After explosion the molecular translational energy of the products of combustion in a closed vessel would fall more slowly than in simple cooling of a hot gas in which equipartition is already established. This would have the same influence on the pressure as would after-burning, and may be the cause, at least in part, of the maintained pressure observed by Clerk in rich mixtures—in which it is shown the pressure efficiency should be the lowest—and of the prolonged radiation observed by B. Hopkinson after the flame stage has ceased.

T. H. P.

1693. *Trouton's Rule.* **C. Sonaglia.** (N. Cimento, 7. Ser. 6. pp. 321–328, May, 1914.)—Cederberg's objection to Nernst's equation (Zeitschr. physikal. Chem. 77. pp. 498–509, 1911), on the ground that it contains no constants relative to the particular compound, is invalid since the boiling-point enters into the equation. Cederberg claims for his own formula that it contains no empirical constants; since, however, it is derived by combining other relations with van der Waals' equation and the values of a are not the same but different for different compounds, this claim is open to criticism.

The author has investigated the values of Trouton's constant for ethyl and propyl formates, methyl and ethyl acetates, acetone, methyl ethyl ketone, diethyl ketone and dipropyl ketone at various temperatures which exactly correspond. Use is made of Nernst's formula,

$$\lambda = (\lambda_0 + 3{\cdot}5T - \varepsilon T^2)(1 - p/\pi_0),$$

in which ε is a constant and λ_0 the latent heat of evaporation at absolute zero. Accurate measurements of λ at two different temperatures give the values of λ_0 and ε, and hence the value of λ at any other temperature, so long as p is small compared with the critical pressure, π_0. For reduced temperatures equal to or greater than 0·5 this condition is not satisfied, and in these cases p was calculated by means of Nernst's formula,

$$\log p = \lambda_0/4{\cdot}571\,T + 1{\cdot}75 \log T - \varepsilon T/4{\cdot}571 + C.$$

The results show that the values of Trouton's constant for the esters become equal at a reduced temperature of about 0·5, whilst at lower temperatures marked variations occur. Nernst's observation that the values at the boiling-point increase with rise of temperature is not confirmed for the values at corresponding temperatures. On the other hand, the curves representing the variation of Trouton's constant with temperature for the last three ketones are similar but do not meet; the behaviour of acetone is complicated by the tendency of its molecules to associate. T. H. P.

1694. *Exact Method for calculating Vapour Pressure.* **I. W. Cederberg.** (Phys. Zeitschr. 15. pp. 697–705, July 15, 1914.)—The author has investigated the dependence on the temperature of the factor a of van der Waals' vapour-pressure equation, $\log(\pi_0/p) = a(\vartheta_0/T - 1)$, and has deduced the simple exponential formula, $a = \alpha \cdot \beta^{(T/\vartheta_0 - \gamma)^2}$, where α represents the minimal value of a, β a constant, and γ the reduced minimum temperature. Combination of this expression with the van der Waals' equation yields a vapour-pressure formula, which allows of the complete representation of the total vapour-pressure curve of any substance. Application of this combined formula to various compounds gives good results, those obtained with water, for example, being in excellent agreement with the latest experimental data from the lowest temperatures to the critical point. Two of the constants in this expression seem to be independent of the nature of the substance, and on this basis an approximation formula is deduced which contains only physically well-defined magnitudes and yields good results, as is shown by applying it to the case of water between 100° and 180°. T. H. P.

1695. *The Partition of Energy.* **J. D. van der Waals, Jr.** (Konink. Akad. Wetensch. Amsterdam, Proc. 16. pp. 1082–1088, May 29, 1914.)—The author corrects, by the introduction of new assumptions, the formula for the dissociation equilibrium of a diatomic gas given in his previous communication [Abstract No. 284 (1914)]. He there shows that Planck's later supposition concerning the existence of a zero-point energy leads to the conclusion that the entropy of a number of particles does not change at the absolute zero-point when they pass from a binding in which they can vibrate with a definite period into another combined state in which they have another period. The simple assumption for a linear vibrator that, besides vibrations with frequency ν, rotations occur with a frequency $\nu' = h/2\pi^2 M$, then leads directly to Nernst's heat theorem as formulated by Planck with a finite value of the entropy for $T = 0$, in place of the value $-\infty$ of the older theory. The author points out that the infinite entropy difference would evidently be evaded only in two ways : (1) By assuming a finite number of distributions of the points of velocity also at high temperature, and (2) by assuming that there are infinitely many also at $T = 0$. The former hypothesis is that of the energy quanta, the second that of the zero-point energy. Each supposition leads to a finite relation of the number of possible distributions at $T = 0$ and at $T > 0$, and hence to a finite entropy difference. Investigation of the energy distribution at higher temperature, assuming that a number of molecules will possess an energy $< \nu h$, and that for them every value of the energy is equally probable, leads to the conclusion that Planck's zero-point energy hypothesis can only be reconciled with the thermodynamic law of the equilibrium-change when the probability function shows a discontinuity at $\varepsilon = \nu h$, of entirely the same nature as had already been assumed by Planck. G. W. de T.

SOUND.

1696. *Combinational Vibrations maintained by Two Simple Harmonic Forces.* **C. V. Raman.** (Indian Assoc. for Cultivation of Science, Bull. No. 11. pp. 1–24, 1914.)—The author previously dealt with a new class of forced oscillations maintained by periodic variations of a spring, of which the longitudinal mode of Melde's experiments is a specific case. It was thus shown that a simple harmonic force (due to a fork) acting longitudinally on a stretched string could maintain its vibrations when the frequency of the string's free oscillations in any given mode were nearly equal to any integral multiple of half the frequency of the fork [see Abstract No. 200 (1913)]. From the photographs of the above vibrations and the mathematical discussion, it became clear that a very important part in the maintenance of the motion is played by certain subsidiary components introduced into it under the action of the variable spring. It was shown that the principal component of the maintained vibration, together with the subsidiary motions thus introduced, could be arranged in the form of a Fourier series, the difference of frequency between the successive terms being that of the variable spring itself. This suggested the present work, in which a horizontal stretched string had its extremities attached to the prongs of two forks placed vertically with their directions of vibration parallel to each other and to the length of the string. Thus, neither fork tends directly to displace the string from its equilibrium position, but varies its tension, so the string remains undisturbed so far as transverse movement is concerned, except when the frequency of free oscillation of the string is adjusted so as to coincide more or less accurately with certain values termed "resonance frequencies." Certain of the resonance frequencies should obviously be multiples of half the frequency of one or other of the forks by itself (say $rN_1/2$ or $sN_2/2$, where N_1 and N_2 are the frequencies of the forks and r and s integers). But, besides the resonances of this kind, the author finds a large number of other cases of vigorous maintenance which have evidently to be ascribed to the joint action of the two forks on the string. Their frequencies may be denoted by $(rN_1/2) \pm (sN_2/2)$, where the positive sign applies to summational resonances and the negative sign to differential resonances.

The paper contains a mathematical treatment of this mode of maintenance, full details of the method of photographing the vibrations, and 12 clear reproductions of them. E. H. B.

1697. *Motion in a Periodic Field of Force.* **C. V. Raman.** (Indian Assoc. for Cultivation of Science, Bull. No. 11. pp. 25–42, 1914.)—Deals with the different speeds at which an electromagnetic phonic wheel or synchronous motor may be run or oscillated. Using a fork interrupter, it was found that the frequency of vibration of the armature wheel might be equal to 1/2, 1/3, 1/4, 1/5, or 1/6 that of the fork (which was about 24 per sec.). The paper includes the mathematical theory, and a series of fine photographs exhibiting the relations of the frequencies of the armature and fork, or of the speed of the armature when continuously run under various excitations. E. H. B.

1698. *Musical Scale.* **A. Vaucher.** (Archives des Sciences, 38. pp. 53–67, July, 1914.)—Additional notes on the mathematical theory of the musical scale discussing specially the functions of temperaments. [See Abstract No. 300 (1914).] E. H. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS AND ATMOSPHERIC ELECTRICITY.

1699. *Method for e/m from Thermionic Currents.* **S. Dushman.** (Phys. Rev. 4. Ser. 2. pp. 121–134, Aug., 1914. Phys. Zeitschr. 15. pp. 681–685, July 15, 1914.)—An experimental research whose chief results are as follows :—(1) The space charge formula developed by I. Langmuir for the thermionic current from a heated filament to a coaxial cylindrical anode has been tested experimentally over a range of voltages from 35 to 140, for the case of a tungsten filament in a concentric molybdenum cylinder. (2) The results obtained are in good agreement with this formula, and indicate that the method ought to prove a very accurate one for the determination of *e/m* (3) The observations obtained on the effect of gases on the thermionic currents are also found to be in accord with Langmuir's surface film theory, and justify the conclusion that there exists a pure electron emission from heated metals which is a function of the temperature only, and is not a secondary effect due to presence of gases as assumed by some investigators. [See Abstract No. 725 (1914).] E. H. B.

1700. *Potential Theory.* **J. G. Leathem.** (Roy. Irish Acad., Proc. 32. pp. 31–50, Sept., 1914.)—An analytical treatment of doublet distributions in the theory of potential. E. H. B.

1701. *Propagation of Electric Waves on a Cylindrical Conductor.* **A. Signorini.** (Accad. Lincei, Atti, 23. pp. 943–949, June 21, 1914.)—Mathematical.

1702. *Electrification of Water by Splashing and Spraying.* **J. J. Nolan.** (Roy. Soc., Proc. Ser. A. 90. pp. 531–543, Aug. 1, 1914.)—The object of the work is to establish a connection between the charge produced on a sprayed liquid and the extent to which it has been broken up. The liquid used is distilled water, and two methods are described for breaking it up in contact with the air : (1) by splashing against an air-blast, (2) by spraying. In the first method drops are allowed to fall into a strong horizontal air current. Each drop is shattered by the blast into a number of varying size, and a rough sorting out is effected as the bigger drops are carried further aside by the blast. The drops chiefly used are the fine ones which enter a measuring vessel placed directly under the dropper, as these are fairly uniform in size. Variations in size can be obtained by altering the height of the dropper or the strength of the air-blast. In the second method an ordinary scent spray is used to form the drops. Measurements are made of the charge carried to the receiving vessel, the volume of water, and the number of drops which enter it (giving the mean size of the drops). It is found that the charge, E, per cm.^{3} of water increases with a decrease in the radius r of the drop. $E = k/r$ where k is a constant. This result is explained simply, on the assumption that the charge on the water is proportional to the area of new water surface created when the drops are formed. Both methods give good agreement in the value of the constant. The air drawn from the sprayer

was examined to find how the negative charge is carried. A detailed account will be given later, but in a *résumé* the author states that the air was found to contain a number of ions of both signs (excess of negative), ranging in mobility from the large ion found by Langevin to the ordinary atmospheric ion. It is probable that the excess of negative charge in the air is present mainly as small ions. T. H.

1703. *Theory of Electrical Dispersion into the Free Atmosphere, with a Discussion of the Theory of the Gerdien Apparatus.* **W. F. G. Swann.** (Terrestrial Magnetism, 19. pp. 81–92, June, 1914.)—Riecke has shown that if a charged sphere is placed in a stream of air it loses its charge at a rate given by $-dQ/dt = 4\pi Qnev$, where Q is the charge on the sphere, n the number per cm.^{3} of ions of opposite sign to the charge Q, v the specific velocity of these ions, and e the ionic charge. The present author brings forward a proof of this formula for the more general case where the charged body is not necessarily a sphere and where the air does not flow in parallel streamlines with uniform velocity. Applying this equation to the Gerdien conductivity apparatus, he finds that the accepted formula by which conductivities are calculated with this apparatus is incorrect, and leads to results 20 % too high. Experimental evidence is adduced in support of this result. A theory of the collection of radio-active deposit by a charged conductor is also given. J. S. Di.

1704. *Notes on the Atmospheric Electrical Potential Gradient in the Industrial Districts around Leeds.* **D. W. Steuart** and **I. Jörgensen.** (Roy. Soc. Edinburgh, Proc. 34. pp. 202–207, 1913–1914.)—The paper gives the results of experiments made to determine the effect which smoke from chimneys has on the potential gradient. Positions on the lee of factory chimneys were taken up, and large positive gradients were invariably found when the smoke passed over the spot chosen. Readings of over 800 volts/m. were commonly obtained at over 1 mile from large chimneys. A position near a railway line was also taken up, and very striking results obtained when the smoke from passing locomotives blew over the position. It is concluded that in these cases of combustion for ordinary commercial purposes many ions are formed, and that most of these are of the positive sign. J. S. Di.

1705. *Protective Range of Lightning Rods.* **J. Larmor** and **J. S. B. Larmor.** (Roy. Soc., Proc. Ser. A. 90. pp. 312–318, May 28, 1914.)—Electric discharge in a gas is a rupture along a line of force, and not over a surface. The initial rupture is to be expected at a place of maximum force, and spreads in both directions along the line of force through that point. In the case of a lightning rod the discharge would start at the summit of the rod, the place of most intense strain, and strike away from the rod. Once a line of disruptive discharge is established, the neighbourhood of a lightning rod can have little effect, and a simple mathematical investigation shows that a thin isolated rod will draw the discharge hardly at all unless in the region around its summit, and that the modification in the field due to a thin rod is negligible along its sides unless close to it. It is the building carrying the rod which modifies the field and directs discharge to its own upper parts, which, therefore, need protection by conductors adequate to draw off this discharge to earth; and vertical rods, joining together, if need be, lower down, but rising from the corners of the structure to a height which need not exceed about half its breadth, will lift up the field of concentrated electric force

from the region directly above the building to the region above their summits, and will so take the discharge. The rods may rise from an earth-connected network spread over the roof, but unless the meshes are fine enough to approximate to a complete metallic covering, it is questionable whether it would in itself protect a building from a discharge striking down upon it. A spread of connected metallic points some height above the building would appear to be more effective, and might even by themselves suffice to take up and guide away any likely stroke. In fact, if we neglect the discharge from the rods into the field, their effect is merely to provide the easiest and most probable path for such discharges as may be attracted by the structure. The discharge from the pointed extremities of the rods adds, of course, to the protective effect by slowly, but continuously, reducing the strain in their neighbourhood, and therefore the liability to disruptive discharge.

G. W. DE T.

DISCHARGE AND OSCILLATIONS.

1706. *Positive Ionisation from Heated Platinum.* **C. Sheard.** (Phil. Mag. 28. pp. 170–187, Aug., 1914.)—This paper presents the results of some investigations made as to the dependence of the positive ionisation from heated Pt-wires upon (1) temporary heatings of the wire when earthed and at temperatures higher than a chosen lower temperature at which the positive thermionic current was subsequently measured; (2) temporary heatings of the wire under negative potential and at such temperatures as to give small negative currents, the positive emission being investigated at an arbitrary, chosen temperature; and (3) heating the wire in a Bunsen flame and in CO_2, and also rewashing in nitric acid. Results show that there is an increase of positive thermionic currents produced in high vacua (*a*) by heating a wire under zero potential at higher temperatures than at which the ionisation is subsequently measured, and (*b*) by heating the wire under negative potential at such temperatures as to discharge negative electricity. A detailed examination is made of the positive currents produced by method (*a*) cited above in dry air at atmospheric pressure. Maximum effects are obtained after heating at 654° and 756° when tested at 628° C. The intimate connection between the decrease of positive thermions produced at temperatures above 756° C. and the liberation of electrons is pointed out, and a general theory given to account for the experimental results obtained. Similar results are obtained by heating the wire in the reducing portion of the Bunsen flame. The rôle played by hydrogen in producing an increased positive emission is discussed, and the theory advanced that hydrogen, through its affinity for electrons, accelerates the production of positive ions by (*a*) inhibiting recombination of positive and negative ions, and (*b*) by removal of electrons. A decreased rather than increased positive ionisation is occasioned by heating in CO_2: a possible explanation is offered. An investigation of the decay with time of the positive currents at different temperatures shows the existence of at least two sources of ions; the first gives decay effects according to an exponential law, the second shows an increase to a maximum followed by subsequent decay with time. [See also Abstract No. 134 (1914).]

A. E. G.

1707. *Emission of Electricity from Various Substances at High Temperatures.* **G. W. C. Kaye** and **W. F. Higgins.** (Roy. Soc., Proc. Ser. A. 90. pp. 430–437, July 20, 1914.)—Experiments have been conducted at temperatures from 2000° to 2500° C. within a carbon-tube furnace at atmospheric

pressure. The procedure adopted is to measure the electrical emission from a particular substance when it is heated in a graphite crucible, and then to repeat the experiment, under the same conditions, with the same or a similar crucible when empty. As the crucible, in some cases, absorbed the fused material and thus became permanently contaminated, the reverse order was, as a rule, the more convenient. For each material tested a new crucible was substituted. Under these conditions the electrical emissions, in the absence of any applied potential, have been measured for a number of substances on their introduction into the furnace. Among the substances tested were the alkaline earths (BaO, CaO, SrO, MgO), soda-lime, alumina (Al_2O_3), oxide of iron (Fe_2O_3), silica (sand), and the metals Sn, Cu, Al, Fe, and brass. Usually the substance was in a state of powder.

In most instances, the effect of suddenly introducing the various substances into the hot furnace was a little violent. A puff of smoke or flame occasionally shot from the furnace mouth, evidence of violent boiling being plainly recognisable in some cases. The absorption of the white light from the incandescent central region of the furnace by the vapour in the cooler parts of the tube imparted, in some instances, a striking colouration to the emitted light. Some of these colours were obviously complementary in tint to those usually associated with thermal excitation. For instance, CaO gave a yellow-green colour, BaO a beautiful salmon-pink, and SrO an intense green ; Al gave a brilliant yellow, and Al_2O_3 a beautiful green. During their rapid volatilisation the substances gave out large amounts of electricity, which, with one exception, was negative in sign. For example, barium oxide and alumina generated negative currents of the order of 4 amps. per cm.^{2}, boiling tin about 2 amps. per cm.^{2}, and boiling iron about 1 amp. per cm.^{2}. Boiling brass, on the contrary, produced a positive current of about 0·5 amp. per cm.^{2}.

The results have interest in connection with the problems of solar magnetism. A. E. G.

1708. *Ionisation produced by Certain Substances when Heated on a Nernst Filament.* **F. Horton.** (Cambridge Phil. Soc., Proc. 17. No. 5. pp. 414–424, May 5, 1914.)—W. Wilson failed to detect any positive ionisation from aluminium phosphate heated on a Nernst filament, although the positive emission from this salt when heated upon Pt has been investigated by several experimenters. He therefore concluded that "the leak observed when the salt is heated on Pt is either mainly a leak from the Pt itself, or the latter plays an important rôle in its production" [see Abstract No. 1206 (1911)]. The author has recently been studying the thermal ionisation produced by Nernst filaments and, having the apparatus at hand, it was thought desirable to test the views as to the origin of the ionisation from glowing solids by ascertaining (*a*) whether lime heated upon a Nernst filament gives a negative emission comparable with that obtained when it is heated upon platinum, and (*b*) whether the positive emission from a glowing Nernst filament is increased by placing sodium phosphate upon it. It has already been shown that sodium phosphate heated upon Pt gives a large positive ionisation which is more permanent than that given by aluminium phosphate. The discharge tube used in these experiments is similar to that previously described, the only difference being that the two parallel Pt plates which form the anode are rather further apart in the present apparatus. These plates are situated vertically 1·5 cm. apart, at the centre of the small bulb which forms the discharge tube. The Nernst filament when in position is parallel to the plates and midway between. It can be heated by an alternating current led in

through stout Pt-wires, and the filament and its leads can easily be removed from, or replaced in, the bulb.

A Nernst filament is heated in a good vacuum (the residual gas having a pressure of 0·0001 mm.) until the negative current obtained from it under a p.d. of 214 volts has become fairly constant. The curve given shows that at temperatures above about 1500° C. the thermionic current increases directly with the temperature, and not in the exponential manner usually obtained with substances heated at lower temperatures. A glowing lime-covered filament is placed in the apparatus and the air-pressure reduced. It is at once obvious that under these conditions the lime gives an enormous negative emission, for, as the pressure is reduced to a few mm. a brilliant glow appears in the discharge tube, without the application of any e.m.f. except that of the heating circuit. One of the Pt-wire leads to the filament was kept earthed, and from the appearance of the discharge it was seen that the bare end of this wire near the filament was acting as an anode. By lowering the temperature of the kathode the luminous discharge could be stopped, but at the lower temperature it could be started again by earthing the parallel-plate anodes of the discharge tube, by touching with the finger. The results described are sufficient to show clearly that the large negative emission obtained from lime heated on Pt cannot be attributed to the metal with which it is in contact. The form of the current-pressure curve for the positive emission from a Nernst filament is exactly similar to that given by Pt. The filament is next covered, except for about 1 mm. at each end, with a layer of pure sodium phosphate, by evaporating a water solution of that salt upon it a few drops at a time. It is then fitted into the discharge tube and the positive emission re-tested. The effect of placing sodium phosphate upon the filament is to reduce the pressure of max. emission very considerably, so that at pressures of a few mm. there is a very much greater ionisation from the phosphate-covered anode than from the filament alone. The ionisation at all pressures is increased by the presence of the sodium salt, but the increase is most marked at pressures of a few mm. The form of the current-pressure curve for a clean filament is similar to that given by a Pt-strip which has been heated for a long time. In the latter case there are strong reasons for believing that the ionisation is due to gas evolved from the heated Pt, and it would appear probable that the ionisation from the Nernst filament is due to a similar cause. Reasons are given to show that the shape of the curves given by pure Pt and by a clean Nernst filament can be explained by ionisation by collisions coming in at certain pressures. The effect of sodium phosphate is probably twofold : (1) it increases the formation of positive ions at the surface of the anode, and (2) it changes the nature of the gaseous material through which the discharge takes place. A. E. G.

1709. *Disintegration of Gaseous Ion Clusters in Electric Field.* **R. D. Kleeman.** (Phil. Mag. 27. pp. 917–942, June, 1914.)—The equilibrium of free ions and clusters under the laws of thermodynamics and mass action simply, and its bearing on the velocity of ions has been dealt with by the author [Abstract No. 743 (1912)]. The disintegration may be affected by an electric field, (1) by increasing the impact between ion clusters and molecules, (2) by completing the separation of an ion from a cluster of neutral molecules, separated by collision which, but for the field, would recombine. Negative ion clusters are experimentally found to be disintegrated through bombardment by neutral molecules, and so, for equilibrium, the free negative ions must continually form clusters. The average life of a negative ion

cluster in air at atmospheric pressure, and not specially dried, is calculated to be $4{\cdot}2 \times 10^{-7}$ sec., and that of the ion $1{\cdot}1 \times 10^{-8}$ sec. In CO_2 results of the same order are found. The velocity of a negative ion cluster is found to be greater than if proportional to an electric field of such magnitude as readily to produce ionisation by collision. For air not specially dried X/p must be not less than 173, where X is the electric force per cm., and p the barometric pressure. Fields of such order cause disintegration through the velocity given to the clusters, the effect increasing with the strength of field as shown by experimental curves. For air, CO_2, and hydrogen, the critical values of X/p are about 320, 640, and 53 respectively. It may happen that for a certain gas pressure and field intensity the chance of a negative cluster breaking up in passing over a given distance is less than the chance of a positive ion producing a new ion by collision. Kinks in the curves afford some indication of the number of kinds of clusters present, and the majority of negative clusters in a gas appear to be of one kind only. The kinks also give the mean free path of disintegration of a cluster. A theoretical expression is obtained for what should be the length if the path of the velocity of the cluster were proportional to the strength of the field, and an expression for the life of an ion cluster is deduced from this. G. W. DE T.

1710. *Ionisation of Gases by Collision and the Ionising Potential for Positive Ions and Negative Corpuscles.* **W. I. Pawlow.** (Roy. Soc., Proc. Ser. A. 90. pp. 398–411, July 20, 1914.)—The method first used by Lenard for measuring the ionising potential for negative corpuscles is used here for both negative and positive particles. The particles are first given a certain velocity before entering the test chamber where they are submitted to a retarding field larger than the accelerating field. If no ionisation by collision occurs, the receiving electrode will receive no charge. The charge obtained by this receiving electrode is plotted against the accelerating field, and, as is well known for negative corpuscles, a linear relation is found, the line cutting the axis at a definite field, *e.g.* 11 volts in the case of hydrogen. In the present experiments the negative particles are got from a hot Pt-strip, and positive particles from hot sodium phosphate. To make sure that the number of particles escaping from the Pt or from the sodium phosphate was not influenced by the field, a constant auxiliary field was used to extract them. For negative particles hydrogen and helium were investigated and ionisation potentials of 11 and 20 volts respectively were obtained, quite independently of the intensity of the source. For positive particles, hydrogen, oxygen, nitrogen, and helium were investigated. In all cases the intensity of emission has an influence. The relation between the charge obtained by the electrode and the accelerating field is not linear, and it is not easy to say definitely where it cuts the axis. For hydrogen, however, it cuts the axis at a point somewhere under 10 volts, showing that the ionisation potential is of the same order of magnitude as for negative particles. This value, though, varies with the intensity of emission—a fact which seems to point to a complicated velocity distribution of the positive particles. On investigation it was found that the negative particles have nearly all the same velocity, whilst the positive particles have their velocities distributed more widely. Thus, though this research shows that the energy required by a positive particle to ionise is of the same order as that for a negative particle, there are certain differences in the actual process. One more example of this is that a negative thermionic current about 10 times smaller than a positive one sometimes gives an ionisation 10 times larger with equal velocities of the carriers. A possible reason

for this difference is that the collisions which result in the ionisation of a molecule of a gas occur much more often in the case of negative corpuscles than in the case of positive ions. This view is confirmed by Townsend's theory of ionisation by collision. J. R.

1711. *Photoelectric Phenomenon presented by Liquid Dielectrics.* **L. Stramp.** (Acad. Roy. de Belgique, Bull. pp. 45–62, 1914.)—Ultra-violet rays have a marked influence on the loss of an electric charge by liquid paraffin, light petroleum, shale oil, and Russian mineral oil, the discharge being accelerated to the greatest extent with liquid paraffin and petroleum positively charged, and with shale oil and Russian mineral oil carrying a negative charge. This effect is regarded, not as a result of ionisation of the air, but as a surface photoelectric phenomenon, since the velocity of discharge for either a positive or negative charge may be diminished or increased at will by mixing paraffin and shale oil. T. H. P

1712. *Theory of the Becquerel-effect.* I. *Photoelectric Investigations with Oxidised Copper Electrodes.* **A. Goldmann** and **J. Brodsky.** (Ann. d. Physik, 44. No. 6. pp. 849–900, July 3, 1914.)—The Becquerel-effect is a change of the potential of an electrode in an electrolyte due to light if the electrode is covered with a thin solid layer sensitive to light, or if the electrolyte contains a substance sensitive to light. The authors postulate that this effect is similar to the Hallwachs-effect and perform experiments to verify their view. The electrode used is oxidised copper. The method of experiment is as follows: The electrode in darkness is given a certain potential. Light falling on it causes this potential to change. An extra current is sent through the electrolytic cell to bring back the electrode to its original potential. This extra current is taken as a measure of the photoelectric current of the electrode at the original potential. Plotting the current-potential curve it is found that the current depends on the potential in the same way as for the photoelectric current in a vacuum, similar curves to those of Richardson and Compton being obtained. The current was found to be independent of the concentration of the electrolyte between the strengths of a N/1 and N/20 solution of common salt. It is independent of the salt used. In neutral solutions it is independent of chlorides, bromides, sulphates, and of nitrates of alkalies and earth alkalies. It is the same whether water or methyl alcohol is used as solvent, and it is not influenced by the dielectric constant of the surrounding medium. Temperature was found to have some influence, the current rising with the temperature. An effect which was named "solarisation" was observed, which is that by continuous exposure to light the current diminishes, and when the light is shut off there is a current in the opposite direction, which current sinks gradually to zero. Solarisation is removed to a very large extent by stirring the liquid, showing that it is an effect of the electrolyte as opposed to the main effect which is due solely to the sensitive electrode. When solarisation is removed by stirring, the current is proportional to the intensity of light. J. R.

1713. *Theory of the Becquerel-effect.* II. *Basis of a Photoelectric Theory of the Action.* **A. Goldmann.** (Ann. d. Physik, 44. No. 6. pp. 901–915, July 3, 1914.)—Goldmann and Brodsky [see preceding Abstract] have shown that there is great similarity between the Becquerel and Hallwachs effects. The former may be explained in a similar way to the latter by the liberation by light of electrons from the electrode. In the Becquerel-effect, however, the electrons must pass through a relatively strong field of a double layer at the

surface of the electrode and emerge into a conducting medium instead of being caught by a surrounding electrode. In this surrounding medium they become slow-moving carriers of electricity. The thickness of the double layer is estimated to be of the order of 10^{-8} cm., whilst the mean free path of the electrons is of the order of 10^{-4}, so that most of them should get through the double layer. As they are all converted into slow-moving ions it is to be expected that the max. photoelectric current should set in when the retarding field has been reduced to zero. This is actually found to be the case. Solarisation [*loc. cit.*] can be explained by assuming that there are not enough positive carriers about to neutralise the electrons, so that the electrode to which the electrons are travelling attains a potential in a direction tending to produce a negative photoelectric current. After a long exposure this back effect may be fairly large, accounting for a kind of fatigue and detracting from the proportionality between the current and intensity of light unless when the electrolyte is being stirred. After the light is shut off the back effect will continue alone, and will gradually diminish to zero till all the negative carriers have been taken from the electrolyte. A discrepancy in this theory of the Becquerel-effect is that currents of the order of 10^{-4} amp. per cm. can be obtained, whilst with the same electrodes *in vacuo* the value is about 10^{-9} amp. The author suggests that this may be because *in vacuo* the double layer has a very large retarding field, whilst in the electrolyte it is reduced in some at present unknown manner. J. R.

1714. *Passage of Kathode Particles through Gases at Low Pressures.* **L. W. McKeehan.** (Phys. Rev. 4. Ser. 2. pp. 140–144, Aug., 1914.)—The object of the work was primarily to determine whether a very narrow pencil of kathode rays is scattered by traversing a high vacuum. An apparatus is described by means of which the rays can be made to pass through an anode, containing a brass tube 5 cm. long, 0·02 cm. internal diam., into a test chamber, 60 cm. long, terminated by another transverse tube serving as a photographic camera. The greater portion of these rays have a speed, determined by deflection in a magnetic field, between $2{\cdot}7 \times 10^9$ and $8{\cdot}0 \times 10^9$ cm./sec. At the lowest pressure used, 5×10^{-5} cm. of Hg, absence of scattering is shown by the fact that the shadow of an obstruction in the tube cast on the photographic plate is that geometrically obtainable by drawing straight lines enveloping the obstruction from a point in the discharge tube. An angle of scattering exceeding 30 seconds of arc could have been detected. Scattering becomes apparent at a pressure of gas in the chamber of 3×10^{-4} cm. of Hg, but even at $1{\cdot}2 \times 10^{-3}$ cm. the geometrical pattern on the plate, though faint and overlaid by the impression due to scattered radiation, was of the same size and as sharply defined as at lower pressures. The conclusion is, that at this pressure a considerable number of electrons must have free paths in excess of 60 cm. According to Franck and Hertz, slow kathode rays, for the case discussed, should have paths of 3·4 cm., according to Townsend 6 cm. This suggests that high-speed kathode rays must in many cases pass through the atom without measurable change in direction. Positive rays were shown to be much scattered at pressures which did not affect kathode rays. An attempt was made to deduce the law of scattering of kathode rays from the impression of scattered radiation on the plate. Reasons for failure and for the advisability of attacking the problem in another manner are given. T. H.

1715. *Attempts to produce the Rare Gases by Electric Discharge.* **T. R. Merton.** (Roy. Soc., Proc. Ser. A. 90. pp. 549–553, Aug. 1, 1914.)—The

author has made attempts to produce the rare gases by the passage of an electric discharge in hydrogen by a method differing essentially from that employed by Collie and Patterson, or by Strutt [see Abstracts Nos. 1036 (1913), 1102 (1914)]. Although many experiments were made with electrodes of Al, Cu, Ni, Ag, Pt, and Pd, no traces whatever of the rare gases could be found so long as extreme precautions were taken for the exclusion of air. Argon found to be present in some experiments was shown to be due to a minute continuous leak of air, and the author suggests that the appearance of argon rather than neon might be used as an extremely delicate test for air leakage.

F. J. H.

1716. *Production of Rare Gases by Electric Discharges.* **J. N. Collie.** (Roy. Soc., Proc. Ser. A. 90. pp. 554–556, Aug. 1, 1914.)—Making use of the apparatus employed by Merton [see preceding Abstract], the author has examined the gases given off from metallic uranium by bombardment with kathode rays produced by a discharge in hydrogen. When a coil with a Pt break was used the residual gases after the removal of CO_2, water-vapour, and nitrogen (produced most probably from a nitride of uranium) were invariably neon, helium, and a minute trace of argon. The relatively small quantity of argon present makes it highly improbable that the gases were derived from a leak of air. The gases were not produced when a larger coil provided with a mercury break was used for the production of the kathode rays, neither could they be obtained from the Ur by heating.

Further experiments are in progress. F. J. H.

1717. *Absorption of Gases in the Discharge Tube.* **F. H. Newman.** (Roy. Soc., Proc. Ser. A. 90. pp. 499–506, Aug. 1, 1914.)—Mey has shown that the liquid alloy of Na and K when used as kathode in a discharge tube absorbs nitrogen and hydrogen at a rate much greater than than of the absorption of gases by the walls of the tube [see Abstract No. 1433 (1903)]. It has also been shown by Stark that mercury placed near the kathode in a discharge tube absorbs oxygen. It is here shown that the liquid alloy of Na and K absorbs nitrogen and hydrogen when used as anode, though not to the same extent as when kathode. Also, if the discharge is passed between Al electrodes the alloy absorbs these gases. It is also shown that mercury absorbs oxygen when used as anode, but not to the same extent as when used as kathode. The absorption depends considerably on the pressure in the tube, increasing as the pressure diminishes, the quantity of electricity passing being the same. The quantity of electricity is measured in terms of the volume of hydrogen liberated in a voltameter. The alloy absorbs about 3 times the volume of gas liberated in the voltameter at a pressure of 0·3 mm. Hg, whilst at a pressure of 10 mm. the volume of N or H absorbed is only about 1·5 times the volume of hydrogen liberated in the voltameter. Similar amounts apply to the case of oxygen absorbed by mercury. An explanation of the absorption of gases is given, following the discovery of Strutt of a chemically active modification of nitrogen. It is shown that the absorption of nitrogen by the Na-K alloy causes a formation of nitrides of the metals by passing moist air over the alloy, and then into water, where the Nessler test for ammonia is applied. Evidence for this active state of nitrogen is given by passing nitrogen through a discharge between extra electrodes, and then over the alloy. The gas is then passed into water, where the Nessler test showed the presence of ammonia. When the nitrogen was not previously passed through a discharge tube no trace of ammonia was found. The larger

absorption at the kathode than at the anode may thus be due to the fact that the electric force at the kathode is larger, and thus there is more active gas there. Another possible explanation of the large kathode absorption is, that it is the positive rays which are absorbed. J. R.

1718. *Brush Discharge Phenomena produced by Continuous Potentials.* **S. P. Farwell.** (Phys. Rev. 4. Ser. 2. pp. 31–39, July, 1914.)—With a large p.d. between a wire and neighbouring conductors, such as a similar and parallel wire, or a coaxial cylinder, the discharge phenomenon known as "corona" is likely to occur. For alternating p.d.'s this phenomenon has been extensively studied, but the corona produced by continuous potentials has not received so much attention. Watson [see Abstract No. 886 (1910)] has experimented on wires as small as 0·7 mm. and at pressures as low as 360 mm. Schaffers [Abstract No. 1716 (1913)] has worked with cylindrical fields, using wires as fine as 0·006 mm. and various sizes of tube, and has determined the critical voltage for visual corona at atmospheric pressure. The present paper deals with a study of the corona as produced by continuous potentials for wires from 0·037 mm. to 1·285 mm. diam. and tubes 3·50 cm. and 4·45 cm. in diam. The relation between the p.d. and the current between wire and tube has been studied for atmospheric pressure for the different sizes of wire; the critical voltage for visual corona has been obtained for pressures from somewhat above atmospheric down to 2·0 mm. of Hg, and the character of the discharge noted; the effect of variation of voltage for a constant low pressure has also been investigated. Special attention is paid to some of the phenomena observed at low pressures, to the influence of a short arc in series with the apparatus upon the character of the discharge, and to the increase of pressure in the tube due to the ionisation. Numerous photographs are reproduced. [See also Abstract No. 1595 (1914).] A. W.

1719. *Effect of a Longitudinal Magnetic Field on Spark Potentials.* **R. F. Earhart.** (Phys. Rev. 4. Ser. 2. pp. 135–139, Aug., 1914.)—A continuation of a former paper [see Abstract No. 1099 (1914)]. The author concludes that, using parallel plate electrodes, electric and magnetic fields parallel: (1) Spark potentials for pressures above the critical pressure are unaffected by the longitudinal magnetic field. (2) Those below the critical pressure are decreased by such a field. (3) When the pressure exceeds the critical value, the existence of the field requires a higher potential to maintain the discharge than if no field existed. (4) The variations noted in (3) are increased with increasing fields and become larger as the gas pressure is increased. T. H.

1720. *Method of directly measuring the Time of Propagation of Electric Waves on the Suface of the Globe.* **H. Abraham, A. Dufour,** and **G. Ferrié.** (Comptes Rendus, 159. pp. 38–40, July 6, 1914.)—The method employed is derived from that which in 1911 had enabled Claude, Driencourt, and Ferrié to ascertain between Paris and Bizerta that signals travelled with a speed comparable to that of light. It is in sum that of reciprocal strokes formerly utilised for the measurement of the speed of sound, but adapted to wireless telegraphy. A station A_1 sends the first signal to which A_2 responds by a second signal. At A_1 the time T_1 is noted which elapses between the departure of the first signal and the return of the second; and at A_2 is noted the time T_2 which has elapsed between the reception and emission of the same signals. It is clear that T_1 should be greater than T_2, and that $T_1 - T_2$ represents the time of the passage to and fro. For the experi-

ments photographic micro-galvanometers were used in connection with galena detectors. At the moment of passage of a train of waves the galvanometer receives a percussion which gives a sharp angle on the photographic trace. It is the instant of this percussion that it is essential to mark. For this purpose there is photographed on a band of sensitised paper, which is in continuous motion, the image of a fixed slit illuminated by instantaneous flashes at each oscillation of a tuning-fork. Besides the galvanometric trace there is inscribed thus on the photographic paper a series of transversal lines corresponding to definite periods between which interpolation is easy. The precision is necessarily limited by the uncertainty of the micrometric points and by the irregularities of the movement of the paper, but the mean of several inscriptions afford a precision of 1/100000 sec. Musical sparks, as used between Paris and Washington for these observations, do not afford accuracy sufficient to mark the first constituting the signal at very long range, and the error may amount to the interval between two of the sparks. Series of trials were made between Paris and Toulon, Paris and Toul, and Paris and Washington. The conclusion is reached that wireless waves travel along the surface of the globe at an apparent speed slightly less than that of light. E. O. W

1721. *Hertzian Wave Transmission along Helical Wires.* **F. Bourcier.** (Comptes Rendus, 158. pp. 1882–1884, June 22, 1914.)—Using a method of measurement due to Gutton [Abstract No. 1053 (1898)], the author finds the time of transmission along a helix to be always less than along a straight wire of equal length. In a closely wound helix the loss by reflection reduces the intensity to an amount too small to be measurable. When the axial length of the helix is gradually increased by increasing the distance between successive turns a minimum time of transmission is observed at a certain stage, depending on the dimensions of the helix. The intensity attains a value practically indistinguishable from the maximum long before the helix is completely transformed into a straight wire. G. W. DE T.

1722. *Energy used by Transmitters of Small Wave-length.* **G. Leimbach.** (Jahrbuch d. Drahtlosen Telegraphie, 8. pp. 409–429, May, 1914.)—The purpose of the author's experiments was to see how far the energy taken up by small transmitters could be increased, the transmitters having dimensions of the same order as those of Hertz (wave-length < 2 m.). The oscillating energy (E) in such a system is $E = N\frac{1}{2}CV^2$, where N is the spark frequency. The amount of energy stored can be increased by (1) increase of capacity, (2) raising the voltage, and (3) increasing N. If C is increased the wave-length is altered, and if the wave-length is to be kept constant the inductance must be simultaneously reduced. Increasing the energy by increase of V leads to large damping in the spark-gap. The third possibility gives rise to arcing.

A form of sender used by the author consists of two parallel discs forming the condenser in between which the spark-gap is placed. The distance apart of the discs is adjustable, and small conical tubes mounted on the discs form the antenna. The transmitter was excited by a small spark coil whose primary energy was kept constant. The receiver was a resonant circuit with contact detector and mirror galvanometer. With a spark-length of $\frac{1}{10}$ mm. the capacity was varied between 10 and 500 cm., the primary energy remaining constant. As the capacity was decreased the galvanometer deflections rose, since with constant charging current the number

of discharges varied inversely with C. This held until the capacity of the condenser was smaller than that of the spark-gap and the antenna. From the experiments the author deduces :—(1) The Hertzian type of sender is specially suitable for senders of small wave-length. (2) The energy radiated is principally determined by the capacity. (3) Condensers parallel to the spark-gap and also spark-gaps having a high capacity are useless, and waste energy.

The second part of the investigation was directed to the influence of the increase of V. The table below reproduces the results :—

Spark length, mm.	0·1	0·2	0·3	0·4	0·5	0·6	0·8	1·1	1·5
Galv. deflection	2·5	3	11	13	13	15·5	17·5	20	21

From this table it will be seen that the received energy initially rises approximately as the square of the spark-length. A Schloemilch detector was used for this test. The falling-off at greater spark-lengths is explained by the reduction in N with constant current as the potential increases. The substitution of a contact detector gives quite different results :—

Spark-length, mm.	0·1	0·3	0·5	0·7
Galv. deflection	100	54	34	26

The explanation of this result lies in the fact that at the small spark-lengths the charging current being constant, the spark frequency is higher and the type of detector used integrates the individual impulses. The resultant effect is that received energy due to N rises more rapidly than the energy due to V^2. Further experiments are quoted, using subdivided and other types of gap.

The third part of the paper investigates the influence of N. Using continuous current it was easy to vary N by increasing the charging current. The effect of this is seen in the following table :—

Charging current, amps.	$1·7\times10^{-3}$	$2·9\times10^{-3}$	$5·1\times10^{-3}$	$10·0\times10^{-3}$	$14·3\times10^{-3}$
Received current, divns.	1·6	24	42	96	144

The paper concludes with experiments on the spark frequency, using spark-gaps from which air was excluded (Lepel gap), gaps in hydrogen, and vacuum spark-gaps. H. H. H.

1723. *The Propagation of Electromagnetic Waves in Wireless Telegraphy.* **G. R. Dean.** (Electrician, 73. pp. 896–898, Sept. 11, 1914.)—The first Part of this contribution was mentioned in Abstract No. 1110 (1914). The second Part deals with the Hertzian element in an imperfect dielectric; Part III. with the simple Hertz element.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

1724. *Electrical Conductivity of Alloys of Copper and Tin.* **N. A. Puschin** and **A. V. Baskov.** (Russian Physico-Chem. Soc., Journ. 45. pp. 746–752, 1913.)—The curves showing the variation of (1) the specific resistance, and (2) its temperature-coefficient with the composition of copper-tin alloys consist each of six branches, corresponding with the following ranges of composition (atom. % of Sn) : 0–7, 7–20, 20–25, 25–40, 40–50, 50–100. The resistance curve shows a minimum and the temperature coefficient curve a maximum at 25 atom. % of Sn, the magnitude of the coefficient being similar to the values obtained for pure metals; these results indicate the

existence of a definite chemical compound, Cu_3Sn, and are in agreement with those of thermal analysis, etc. The low value of the temperature-coefficient corresponding with the composition Cu_4Sn indicates the formation, not of a definite compound, but of a solid solution.

Whilst the addition of tin to copper causes a very rapid increase in the resistance, copper produces but little change in the resistance of tin.

T. H. P.

1725. *Electrical Conductivity of Liquid Sulphur Dioxide: New Photoelectric Phenomenon.* **J. Carvallo.** (Journ. de Physique, 4. Ser. 5. pp. 387–399, May, 1914.)—The conductivity of liquid sulphur dioxide, determined by means of a Wheatstone bridge and an alternating current, varies considerably with its method of preparation. (A) When it is purified by repeated fractional distillation in a vacuum in diffused daylight its conductivity at 15° is about 10^{-7} "practical" or ohm-cm. units. (B) If such a sample is exposed to daylight for several days the value increases to as much as 10^{-6}. (C) If, however, the fractional distillations are replaced by fractional rectifications in a vacuum and with complete protection from daylight, the value is about 5×10^{-9}, which is maintained as long as the sample is kept in the dark. The increased conductivity resulting from the action of light is explained by the slight decomposition of the sulphur dioxide by ultra-violet light ($\lambda < 390$), according to the equation, $3SO_2 = S + 2SO_3$. The conductivity of sample (A) is diminished very considerably (from $57{\cdot}8$ to $0{\cdot}18 \times 10^{-10}$) by the passage of a continuous current, and this effect is far more marked (from 3190 to $1{\cdot}6 \times 10^{-10}$) with sample (B) which has been exposed to the light; with sample (C), however, such effect is scarcely perceptible. The changes in (A) and (B) are attributed to an electrolytic purification of the sulphur dioxide.

The photoelectric sensitiveness of very dilute solutions of sulphur and sulphur trioxide in liquid SO_2 has been investigated, the results indicating that the action of light is of a twofold character: (1) A positive effect, which causes gradual increase of the conductivity and due to the chemical change expressed by the equation given above. (2) A negative effect, which must be regarded as a property of solutions of the products of the photochemical reaction in excess of the initial liquid; it is, indeed, coexistent with these products, and is determined by the action of light on the electrical, and not on the chemical, properties of the liquid. This negative effect is not felt when alternating currents are employed.

T. H. P.

1726. *Electrical Properties of Silver Sulphide.* **F. A. J. FitzGerald.** (Amer. Electrochem. Soc., Trans. 25. pp. 393–413, 1914.)—The electrical properties of silver sulphide, which has a negative temperature coefficient of resistance, have been studied in connection with its use in an automatic fire alarm [see Abstract No. 44B (1914)]. The sulphide is found to be a solid electrolyte well suited for investigations on compounds of this class. The temperature-resistance curve shows a critical point at a certain temperature, but this is not the same on the heating and cooling curves. The curve is considerably affected by the presence of small proportions of impurities, such as copper, and even very slight chemical reduction has a marked effect on the resistance. Lack of homogeneity in the sulphide made from silver-copper alloy has an important influence on the resistance and probably also on the thermoelectric and rectifying effects. Silver-silver sulphide and copper-silver sulphide form thermoelectric couples. Electrolysis may occur in a Cu | Ag_2S | Cu_2S | Cu cell in a 25-$\sim$ alternating-current circuit, with the result that the cell is eventually short-circuited, but

if the electrodes are of silver the cell is not short-circuited. In the former case, this is probably due to a persistent rectifying effect, any such effect gradually disappearing when silver electrodes are used. With the latter cell, there is a critical temperature at which the rectifying effect disappears and a different one at which it reappears on cooling; these temperatures may be correlated with the critical points of the temperature-resistance curves.

T. H. P.

1727. *Electrical Resistance and Optical Properties of Thin Layers of Platinum.* **B. Pogány.** (Phys. Zeitschr. 15. pp. 688–690. July 15, 1914.)—Planck has recently given results for the optical properties of thin layers of copper [see Abstract No. 1676 (1914). In order to explain his results he supposes that with layers of very small thickness the free path of the free electrons decreases, which means, in Drude's theory, that the frictional resistance becomes greater. Thomson [see Abstract No. 1522 (1901)] has shown from his theory of metallic conduction that if λ is the mean path in massive metal, d the thickness of the layer, then the diminished path λ' is given by $4\lambda' = d[3 + 2\log(\lambda/d)]$, the formula holding good for layers whose thickness is at least of the order of magnitude of the mean path. It follows from this that the specific resistance increases with decreasing thickness of layer, as Patterson as already shown. Measurements have now been made with thin layers of Pt and of Ag. The present paper deals with the results obtained with Pt. The layers were obtained by kathodic deposition, and then the resistances were measured by a Wheatstone bridge method. The thickness of the deposit was estimated from weighings made with a micro-balance which was sensitive to about 4×10^{-6} gm. The results thus obtained are based on the assumption that the density of the deposit is independent of the thickness. On plotting the results it is seen that the specific resistance for relatively thick layers is constant until a thickness of 7 $\mu\mu$ is reached. When the thickness decreases beyond this value, the specific resistance increases rapidly. Following Planck, an investigation was then made to see whether the observed variation of electrical conductivity was accompanied by variations of the optical properties. The indices of refraction and absorption for different layers were obtained, using a Fuess spectrometer. The curves show a general qualitative agreement with the theoretical conclusions of Planck. With the exception of the curve for $(n^2 - k^2)$, the curves all exhibit similar effects to those obtained by Planck for thin copper layers. For the curves showing the values of k and $2nk$ for different thicknesses, characteristic maxima were found; the curve for n showed a steady fall with increased thickness. The maximum of $2nk$ is perhaps slightly more marked than for copper, and the variation of n with the thickness is less than for copper. The curve for $(n^2 - k^2)$ shows a sharp minimum at about 7 $\mu\mu$. Above this value n and k vary only slowly, and their values for a thickness of 26 $\mu\mu$ approximate to those for massive Pt.

A. W.

1728. *Resistivity of Silver.* **E. F. Northrup.** (Frank. Inst., Journ. 178. pp. 85–87, July, 1914.)—The author extends his investigations of the resistivity of metals to the case of pure silver throughout a range of temperature from 20° to 1340° C. The silver is first dealt with as a soft drawn wire, its resistivity being determined between 20° and 60° C.; it is then used in a container which can be heated above the melting-point of silver. Results are plotted in a set of curves. Within the limits of accuracy of measurement, the increase of resistivity from 20° to 60° C. is found to be linear. For the

wider range from 20° to 960° C., corresponding to the solid state, the resistivity curve shows slight convexity towards the temperature axis. At the moment of fusion the resistivity suddenly increases from about 8·5 to 16·6 microhms-cm. Making allowances for shrinkage in solidifying, the author considers that the ratio of resistivities after and before fusion may be taken as 1·98. Within similar limits of accuracy it is found that the resistivity of silver in the molten state increases linearly from its melting-point to 1340° C., which was the highest temperature measured. R. A.

1729. *Thermoelectric Forces produced by Deformation, and their Application to the Measurement of Elastic Hysteresis.* **K. Baedeker** and **W. Vehrigs.** (Ann. d. Physik, 44. No. 5. pp. 783–800, June 19, 1914.)—In a circuit consisting of one single metal thermoelectric forces can be produced by having the circuit unequally heated and subjecting it to deformations which vary from point to point, *e.g.* if a wire is bent so that one part can be kept hot and another cold, whilst a straight portion of it is extended, thermoelectric forces are produced. Considering a rectangular parallelopiped with its edge parallel to the chief axes of pressure, the thermoelectric forces along these directions may be expressed in terms of the pressures as follows, assuming the deformations to be within the elastic limit: $e_x = c_e X_x + c_t Y_y + c_t Z_z$; $e_y = c_t X_x + c_e Y_y + c_t Z_z$; $e_z = c_t X_x + c_t Y_y + c_e Z_z$: the two constants c_e and c_t being involved. For a simple extension we get $e_x = c_e X_x$, and $e_y = e_z = 0$. Other simple expressions are given for the cases of (1) homogeneous pressure, (2) torsion, (3) a tube under internal and external pressure. Various metals were investigated in the form of tubes within the elastic limit, and the linear relations were found to hold fairly well. The tube was bent in such a way that an upper bend in the tube was kept at 100° C. and the lower portion at 0° C., the vertical portion joining the two bends being subjected to extension, compression, torsion, etc., modifications being introduced for the various special cases.

This principle was applied to the measurement of elastic hysteresis, curves being obtained similar to the familiar curves of magnetisation, here of course, the abscissæ being of the dimensions of pressure, and the ordinates microvolts per degree. In one case—a steel tube—a complete hysteresis curve was obtained between equal positive and negative pressures. This involves many difficulties, and so most other cases investigated were for either positive or negative pressure. Just as in the magnetic case, a reversible effect is obtained for small variations of the pressure. When no hysteresis occurs, *i.e.* for small variations, it was proved that the effects due to two distinct influences are additive. When hysteresis is present, one influence modifies the hysteresis due to another influence very considerably, just as in the case of magnetisation with the application of pressure or torsion. The following examples of this are given: Hysteresis of extension during the application of (*a*) an internal pressure, (*b*) a constant torsion, (*c*) magnetisation, and (*d*) hysteresis of torsion during the application of a constant torsion. With soft metals it was found that the thermoelectric forces are proportional to the tension and are reversible until flowing occurs, when a permanent effect sets in. The suggestion is made that the explanation of these effects will most probably be found along lines similar to the molecular theory of magnetism.

J. R.

1730. *An Application of Electrolytically-produced Luminosity, forming a Step towards a Form of Telectroscopy.* **L. H. Walter.** (Roy. Soc., Proc. Ser. A. 90.

pp. 437–440, July 30, 1914.)—The author has investigated the conditions under which it should be possible to make practical use of the luminosity of anodes of alloyed aluminium forming part of a "valve" cell arrangement. The alloy known as "duralumin" is found to give the best results, and with sodium tungstate solution as electrolyte, corrosion is practically eliminated when this alloy is used as the anode. The difficulties with immersed anodes led the author to employ anodes which are completely dry, except as regards the front surface, which is kept wetted by means of a layer of electrolyte caused to flow down it in a continuous stream, the flow being distributed by using a transparent crêpe screen which clings to the anode surface. In this way, the anode being dry at the back, electrical connection can be directly established there, without the great care as to insulation otherwise needed. This arrangement permits of the construction of an apparatus having a multiple anode, comprising a vast number of equal units in quite a small compass, each such unit being able to be rendered luminous in any order or sequence desired and at a speed of some hundreds of times per sec. In the author's experimental apparatus there are over 5000 such separate units in a space the size of a cabinet photograph, or at the rate of over 24,000 per sq. ft.—a number which it would hardly be possible to obtain by other means. Such an apparatus is capable of being employed as a receiver in photo-telegraphy for the reproduction of pictures, etc., especially where these are received as electrical impulses. It constitutes a step towards one form of telectroscopy, the luminous reproduction at some receiver, of an object visible at some distant electrically-operated transmitter. AUTHOR.

1731. *An Interference Oscillograph.* **A. Guyau.** (Journ. de Physique, 4. Ser. 5. pp. 195–206, March, 1914.)—The microscope is frequently employed nowadays not only in the Science laboratory, but also industrially, for observing and photographically recording small movements. The author has designed an apparatus [see also Abstract No. 1056 (1913)] which records, by interference, oscillations of the order of 1/100000 mm. A small mirror is mounted on the vibrating surface. In front of the mirror a second mirror is placed so that a thin layer ($\frac{1}{2}\frac{1}{0}$ mm.) of air intervenes. A beam of light is concentrated on the air space by means of two lenses, and through a system of prisms interference fringes are projected on a horizontal screen. In front of the screen is placed a recording drum which is given a helical motion, and the movement to be observed is recorded in oblique co-ordinates. Knowing the distance apart of two consecutive fringes, V, and the orthogonal displacement v, the displacement u of the moving surface is connected by the relation $u = \lambda v/2V$. The design and construction of the necessary apparatus is very fully gone into by the author, but it is not possible to reproduce the illustrations, and the paper should therefore be referred to. H. H. H.

1732. *A Null Method of Testing Vibration Galvanometers.* **S. Butterworth.** (Phys. Soc., Proc. 26. pp. 264–272; Discussion, pp. 272–273, June, 1914.)—The methods usually employed in the determination of the constants of a vibration galvanometer involve the measurement of a deflection under three different conditions. Two of these deflections can only be obtained very approximately. By extending the theory of the vibration galvanometer it is shown how the constants may be determined by methods which involve only the measurement of one deflection. The remaining measurements are carried out on an alternating-current bridge, and the results obtained are practically independent of the wave-form of the source. The principle of the method

depends on the fact that a vibration galvanometer behaves as a parallel combination of a conductance, a capacity and an inductance, in series with a resistance. It is shown how to balance such a combination, and the method is illustrated experimentally. The constants of various galvanometers are quoted in order to show the applicability of the method. Other uses of the bridge are suggested. AUTHOR.

1733. *Alternating-current Method of comparing an Inductance with a Capacity.* **J. P. Dalton.** (Phil. Mag. 28. pp. 37–44, July, 1914.)—The author discusses the methods of Maxwell, Rimington, and Pirani for comparing self-inductance with capacity. He shows that in the two latter methods the conditions of balance, when alternating current is used, are only true for one particular frequency. He describes a method in which, as in Anderson's, an exact balance is obtained at all frequencies, and the method is therefore called a continuous balance one. The condenser is inserted between one corner of the bridge and a point on one of the opposite arms. F. E. S.

1734. *Einthoven String Galvanometer.* **A. C. Crehore.** (Phil. Mag. 28. pp. 207–224, Aug., 1914.)—Gives the mathematical theory of this instrument, and obtains formulæ. It is hoped in a future paper to give experimental results for comparison and for determination of the constants involved. E. H. B.

ALTERNATING CURRENTS AND MAGNETISM.

1735. *Initial Permeability of Iron and Magnetite as a Function of the Temperature.* **P. Weiss** and **K. Renger.** (Archiv f. Elektrotechnik, 2. pp. 406–418, 1914.)—Starting from the experimental result of Rayleigh and others that $\mu = a_\rho + b_\rho H$, where a_ρ and b_ρ are constants, rings of electrolytic iron and artificial magnetite were investigated by a ballistic method over a range of temperature $-200°$ to $800°$ C. For iron it was found that a_ρ, the initial permeability, was a simple function of the saturation intensity at the same temperature. A change of state was observed to take place in iron at 220° C., and besides the already known temperature 130°, at which ageing takes place most rapidly, a second temperature was found at 330° which is separated from the first by a range of temperature, beginning at 150°, within which ageing does not take place. By subjecting the specimen to six or seven alternations of temperature between 800° and 700° C., a very high initial permeability of 755 was obtained at ordinary temperature. This value fell rapidly with time to about 100. With regard to the creeping or slow growth in intensity in a given field, it was found that magnetisation took the longest time at a temperature of $-11°$ C. In the case of magnetite, the value of a_ρ has a maximum at $-138°$ C. besides that at 568° C. After the first thermal treatment, the initial magnetisation was independent of the previous history and unaffected by the course of the magnetic fields. [See also Abstract No. 525 (1911).] G. E. A.

1736. *Properties of Magnetically-shielded Iron.* **E. Wilson.** (Roy. Soc., Proc. Ser. A. 90. pp. 343–349, July 1, 1914.)—In continuation [see Abstract No. 1330 (1914)], experiments were made with stalloy rings at high temperatures. By allowing the material to cool through the critical temperature while shielded from the earth's magnetism and subjected to a field of about

3 gauss, the permeability was greatly increased, and values of μ higher than 10,000 were obtained. The higher max. permeability in low fields was accompanied by lower permeability at higher values of the induction. The hysteresis loss is lower than in normal stalloy for a given magnetic induction. [See also Abstract No. 1229 (1911).] G. E. A.

1737. *Magnetisation in Rapidly-oscillating Fields.* **H. Rohmann.** (Ann. d. Physik, 44. 6. pp. 817–848, July 3, 1914.)—A magnetised bar is more or less demagnetised when placed in an oscillating magnetic field of which the amplitude continuously decreases. On the other hand, an unmagnetised bar may be magnetised by means of the discharge of a battery of condensers. The magnetism produced depends partly on the amplitude of the alternating magnetic field and partly on the manner in which the field diminishes to zero. Further, the magnetising action of a damped vibration changes qualitatively even when its course is changed by a definite but relatively small amount. Experiments are described showing the effect of the superposition of two damped sine oscillations which give rise to more complicated vibrations. G. E. A.

1738. *Magnetic Induction in Heusler Alloys at High Frequencies.* **H. Fassbender.** (Archiv f. Elektrotechnik, 2. pp. 475–489, 1914. Communication from the Physikal.-Techn. Reichsanstalt.)—The alloy investigated had a composition of 14·25 Mn, 10·15 Al, and about 75 Cu. After subjecting the material to thermal treatment and to an ageing process, in order to obtain it in as magnetically soft a condition as possible, the induction was measured in maximum fields of 21·6, 32·4, and 43·2 gauss, for frequencies of 47,200, 65,200, 97,500, and 119,000, the B-curves being obtained by means of a Braun tube. For theoretical confirmation of the experimental values, the differential equation for the field within the specimen, as modified by the skin-effect, was deduced from Maxwell's theory. The solution gives the distribution of the field, the total flux and the mean induction. G. E. A.

1739. *Molecular Field in Diamagnetic Substances.* **A. E. Oxley.** (Cambridge Phil. Soc., Proc. 17. No. 5. pp. 450–451, May 5, 1914.)—Following up the work on specific heats by Nernst and Lindemann, by Debye and by Planck and Einstein, the author treats mathematically the case of a diamagnetic crystalline structure and finds an increase of specific heat corresponding to rotational vibrations. This increase presents a maximum value in the neighbourhood of the fusion-point. Experiment shows evidence of such a maximum for sodium and mercury. [See Abstract No. 446 (1913).] E. H. B.

1740. *Qualitative Method for the Study of the Magnetic Susceptibility of Solutions.* **A. Quartaroli.** (N. Cimento, 7. pp. 159–164, March, 1914.)—By means of truncated conical poles a field is obtained in which a zone of great intensity is separated sharply from one of feeble intensity. The solution to be examined is introduced into a glass tube of 8–10 mm. diam., and above it is placed, carefully and without mixing, coloured water. The tube is then arranged between the poles so that the surface of separation of the two liquids corresponds with the lower point where the poles begin to diverge. When the magnet is excited the water bulges out into the magnetic solution below without sensibly mixing with it, and, if the field is sufficiently intense, a globule of the water becomes detached and remains suspended in the

magnetic liquid. The phenomenon is visible with weak fields and dilute solutions, which yield scarcely perceptible indications by Plücker's or the U-tube method. Naturally, the results become more marked as the specific gravities of the two liquids approach equality. T. H. P.

1741. *Magneto-chemical Phenomena.* **A. Sčukarev [Schükarew].** (Phys. Zeitschr. 15. pp. 670–673, July 1, 1914.)—If two exactly similar Pt plates, immersed in a mixture of 0·05-N ferric chloride and 0·1-N potassium iodide solutions, are electrically connected outside the liquid through a galvanometer, the latter indicates the flow of a current, which diminishes as the reaction proceeds. Many other reacting mixtures exhibit a similar phenomenon, the current being independent of the stirring of the liquid and passing from the larger to the smaller plate, if plates of unequal size are used. When the plates are similar and the solution is placed between the poles of a powerful electromagnet, the magnetic field exerts no influence on the chemical polarisation current when the plates are parallel to the lines of force and symmetrical towards the central line. But if the plates are somewhat unsymmetrically arranged, the field causes a new polarisation current, which is added to the original one and passes from the plate in the more intense to that in the less intense part of the field. No magneto-polarisation is observed when the Pt plates are perpendicular to the lines of force. Marked magneto-chemical effects of this character occur in the case of reactions taking place at the electrodes during electrolysis. T. H. P.

RADIOLOGY AND ELECTROPHYSIOLOGY.

1742. *Applications of the Coolidge Röntgen-ray Tube.* **W. P. Davey.** (Gen. Elect. Rev. 17. pp. 792–798, Aug., 1914.)—The main advantages in the use of the Coolidge tube are (1) the independence of the quantity and the penetrating ability of the rays produced, (2) the ease and rapidity with which the quantity and penetration of the rays may be regulated, and (3) the fact that when the tube is once adjusted to the requirements of the operator it needs no further attention. To bring the tube to any desired adjustment, the operator pulls a handle which regulates the current through the tube, thus determining definitely the quantity of Röntgen rays produced. He then adjusts the voltage across the tube until the penetration is of the desired degree. The radiographs reproduced show what a wide range of work can be done with a single Coolidge tube, and they suggest that this tube is destined to become a precision-instrument of value to the botanist, biologist, and mineralogist, as well as to the physicist and the physician. A. E. G.

1743. *Measurements of Quality and Quantity of Röntgen Rays.* **W. E. Schall.** (Röntgen Soc., Journ. 10. pp. 45–53; Discussion, pp. 53–54, July, 1914.)—The Christen penetrometer is first considered. Christen suggested that the penetrating power of Röntgen rays should be expressed in terms of the thickness of tissue necessary to absorb exactly one-half of the radiation which strikes the skin. The explanation of the method of doing this is given. In the Bauer qualimeter the penetrating power of the tube is indicated on the scale; but the readings may not be taken as absolute readings of penetrating power because they depend too much on the frequency of the interrupter, and the type of Röntgen-ray apparatus used. When, however, the operator has calibrated it to his own installation and knows which reading on its scale corresponds to, say, 7 or 9, etc., Wehnelt, it is very useful to indicate the

penetrating power. Tables comparing the values of the Benoist, Wehnelt, Christen, and Bauer radiometers are given. It should be borne in mind that the penetrating power of the tube ought to be measured with the current which it is proposed to use or else allowance must be made for increasing hardness due to a larger current than the one used for measuring.

There are at present in use two methods for dosage : the indirect and the so-called direct. The relative advantages and disadvantages of these are considered with special detailed reference to the chemical quantimeter of Kienböck and the Ionto quantimeter. A table is given comparing the values of the Sabouraud-Noiré, Holzknecht, Kienböck, Ionto, Hampson, and Bordier quantimeters. In the *discussion*, **G. W. C. Kaye** stated that it was a question in any tube what proportion of the kathode rays generated Röntgen rays : the subject needs much experimental work. Any satisfactory instrument based on an ionisation method must give, at any rate, a constant proportion of the whole of the energy in the Röntgen ray, or some attempt must be made at completely absorbing the Röntgen ray, otherwise one would get the roughest notion which would be of little value. There is the same difficulty with the pastille. A. E. G.

1744. *Spark Inductors and Röntgen Rays.* **C. Déguisne.** (Phys. Zeitschr. 15. pp. 630–638, June 15, 1914.)—The apparatus used is briefly described and curves are given to illustrate the results obtained such as : Curves showing the relationship between primary and secondary currents at different times when a tube of medium hardness is employed, and Current and voltage curves for soft tubes. A. E. G.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1745. *Two New Modifications of Phosphorus.* **P. W. Bridgman.** (Amer. Chem. Soc., Journ. 36. pp. 1344–1363, July, 1914.)—Under the influence of high pressure, ordinary white phosphorus is transformed into a new modification. The transition temperature is a linear function of the pressure and varies from about — 80° at the atmospheric pressure to + 64·4° at 12,000 kg. per sq cm. This modification was obtained in microscopic crystals, probably of the hexagonal system. A black modification has also been obtained by subjecting the ordinary white form to a temperature of 200° and a pressure of 12,000 kg. per sq. cm. This variety, the formation of which is irreversible, has the high density, 2·691, at the ordinary temperature and possesses moderately high electrical and thermal conductivity. Its specific heat between 30° and 100° is 0·170, which is decidedly lower than the corresponding value for red phosphorus, the latter being apparently less stable than the black form. The relations between the different modifications of phosphorus are discussed. [See also Abstract No. 1630 (1914).] T. H. P.

1746. *Adsorption of Acetylene by Palladium-black.* **C. Paal** and **C. Hohenegger.** (Ber. Deut. Chem. Gesell. 46. pp. 128–132, 1913.)—In the authors' previous investigation on the same subject the palladium-black was suspended in aqueous solutions of various substances. They have now investigated the adsorption of acetylene, using either suspensions of palladium-black in pure water, or else dry palladium-black. The experiments in which 60 % alcohol was used in place of pure water were also repeated. In all cases the adsorption of the acetylene takes place slowly, and the results given do not point to any fixed ratio between the weight of Pd and the amount of gas adsorbed. It is probable that the acetylene is not completely adsorbed as such, but undergoes partial polymerisation. When the dry palladium-black is not completely free from oxygen, formation of feeble sparks occur immediately it is brought into contact with the acetylene. T. S. P.

1747. *Separation of Corpuscles in Chemical Reactions.* **S. M. Tanatar** and **E. Burkser.** (Russian Physico-Chem. Soc., Journ. 45. pp. 1–6, 1913.)—Immersion of a charged conductor connected with an electroscope into the gas evolved during the catalytic decomposition of hydrogen peroxide by platinum-black shows the gas to be strongly ionised. A thin Al plate placed under the base of the glass vessel retards the loss of charge. Similar experiments were also made on the oxidation of sodium sulphite or arsenic trioxide by hydrogen peroxide solution. The results do not allow of any definite statement concerning the cause of the ionisation observed. T. H. P.

1748. *Behaviour of Hydrogen towards Palladium.* **A. Gutbier, H. Gebhardt,** and **B[erta] Ottenstein.** (Ber. Deut. Chem. Gesell. 46. pp. 1453–1457, 1913.)—The authors have investigated the absorption of hydrogen by Pd at temperatures varying between — 50° and + 105°. The Pd was used in the form of sponge, which was obtained by heating ammonium palladiochloride in an oxygen-free stream of CO_2, the temperature used being as low

as was consistent with the expulsion of all the ammonium chloride. The results obtained are in agreement with those of Paal and Amberger—namely, that with decrease in the temperature there is a considerable increase in the absorption; they contradict the results of Hemptinne (1899), and of Baerwald (Comptes Rendus, 145. p. 202, 1907). The absorption is a minimum at 20°.

The palladium hydride obtained was pyrophoric. T. S. P.

1749. *Two Lecture Experiments on the Diamond.* **W. Prandtl.** (Ber. Deut. Chem. Gesell. 46. pp. 216–217, 1913.)—Moissan's method of making diamonds may be modified as follows: In a cylindrical can of sheet metal, 10 cm. in diam. by 12 cm. high, is placed another cylinder, open at both ends, of less diam., and the space between the two filled with dry, powdered fluorspar. The inner cylinder is then filled with a mixture of 200 gm. of iron thermit and 10–15 gm. of powdered coke, after which it is withdrawn, so that the thermit mixture is surrounded at the sides by the fluorspar, but is in direct contact with the bottom of the sheet metal can. The can is fixed on an iron ring placed above a vessel containing mercury covered with a layer of 15–20 cm. of water, and the thermit mixture fired. The liquid iron dissolves the carbon, melts through the bottom of the can, and is quenched in the water and mercury. The iron is then treated in the usual way to obtain the microscopic crystals of diamond, which are accompanied by some doubly refracting, hexagonal plates, probably of carborundum.

The combustion of a diamond in oxygen can be conveniently shown by heating it in a quartz test-tube, fitted with a cork through which pass inlet and exit tubes for the oxygen and products of combustion respectively. The combustion of the diamond is started by heating that part of the quartz tube on which the diamond rests with a blowpipe flame. T. S. P.

1750. *Preparation of Cerium and its Alloys.* **M. Moldenhauer.** (Chem. Zeit. 38. p. 147, 1914.)—Cerium oxide is not reduced to cerium by the Goldschmidt method, using either Al, Mg, or Ca. Cerium fluoride is, however, readily reduced by excess of Ca, giving an alloy containing 12 % Ca and about 86 % Ce; it is necessary to cover the crucible with a layer of calcium fluoride during the reaction, in order to prevent oxidation. If the cerium fluoride is mixed with iron oxide, reduction with Ca gives an alloy of Ce and Fe containing 40 % Ce. If the Ca is replaced by Al, an Al (10·2 %)—Ce (25·3 %)—Fe (62·5 %) alloy is produced.

All the above alloys show the properties of the ordinary iron-cerium alloy. T. S. P.

1751. *Atomic Weight of Lead of Radio-active Origin.* **T. W. Richards** and **M. E. Lembert.** (Amer. Chem. Soc., Journ. 36. pp. 1329–1344, July, 1914. Comptes Rendus, 159. pp. 248–250, July 20, 1914.)—In order to test the theory that the nature of the end-product of the process of disintegration of a radio-active mineral will vary according to the proportion of the parent substances in the mineral, parallel determinations have been made of the equivalent weights of various samples of lead chloride from different sources. It is found that all the radio-active specimens possess lower atomic weights than ordinary lead, the deficiency in one case amounting to as much as 0·75 of a unit. No simple linear relationship between the exact amount of radio-activity and the atomic weight is evident. Comparison of the ultra-violet spectrum of a typical radio-active sample with that of ordinary lead revealed only negligible differences. These results appear to lead to the conclusion that radio-active lead contains an admixture of a substance differing from

ordinary lead and very difficult of elimination by chemical means. This substance cannot be identified in the ultra-violet spectrum of the material, because either it has the same spectrum as lead, or it has no spectrum in that part of the field, or its spectrum is masked by that of the lead. These results are contrary to the experience obtained with other elements, notably Cu, Ag, Fe, Na, and Cl, each of which seems to give a constant atomic weight, no matter what the geographical source. The theoretical aspects of the facts presented are not discussed, but attention is drawn to their qualitative agreement with the hypothesis of Fajans and of Soddy [see Abstract No. 1075 (1913)]. T. H. P.

1752. *The Preparation of Sodium.* **B. Neumann** and **S. Giersten.** (Zeitsch. f. angew. Chemie, 27. pp. 65–70, 1914.)—The authors have constructed a large, experimental apparatus, on the principle of the Castner apparatus, for the preparation of sodium by the electrolysis of fused sodium hydroxide, using, however, a special arrangement by which the water formed at the anode is evaporated largely by the heat of the fusion and is prevented from coming into contact with the sodium at the kathode. The best conditions of current and temperature were investigated, and are discussed in detail, as also the various phenomena which occur during electrolysis. The most important factor for successful electrolysis is the temperature, which, in the katholyte, must be maintained very close to that of the melting-point of the sodium hydroxide. Pure sodium hydroxide does not give such good results as the commercial substance, owing to its high melting-point. Current yields of 53 % were obtained, whereas the average yield in the manufacturing process is 30 to 40 %.

The details of the authors' experiments and considerations can only be appreciated by reference to the original paper. T. S. P.

1753. *Heats of Cooling of Aluminium, Iron, Antimony, and Nickel.* **P. N. Laschtschenko.** (Russian Physico-Chem. Soc., Journ. 46. pp. 311–333, 1914.)—The amounts of heat developed by these metals during cooling were measured in the manner previously described [Abstract No. 1530 (1913)]. The aluminium used contained 0·31 % Si and 0·63 % Fe, but was free from copper and lead. The curve connecting the amount of heat developed by 1 gm. of Al in cooling from any given temperature to 23–24° with this temperature, is continuous to 580°, and is somewhat convex towards the temperature axis. Between 580° and 590° a marked change in the direction of the curve occurs, and at 670–650° a sudden increase in the amount of heat, owing to fusion of the metal. The heat of fusion is found to be 71 cals. per gm. Even when the metal is melted and heated at 700–720° it exerts no action on the quartz tube, and only at 750° does the formation of Si occur.

In the experiments with iron, the metal used was free from pearlite, and contained only minimal inclusions of slag. The heat-of-cooling curve shows two marked changes in direction, at 730° (α-Fe $\rightleftarrows$ β-Fe) and 895° (β-Fe $\rightleftarrows$ γ-Fe) respectively, and beyond 900°, when the iron is in the γ-form, the specific heat increases rapidly with rise of temperature. Measurement of the heat of cooling of electrolytic iron confirms the temperature 730° for the change of α- into β-iron. The conversion of the β- into the α-modification is accompanied by the development of 5 cals. per gm. or 0·28 cal. per gm.-atom, and that of γ- into β-iron by about 6·1 cals. per gm. or 0·38 cal. per gm.-atom.

The nickel employed was of 99·89 % purity. The heat-of-cooling curve shows a break at 355–365°, in complete agreement with previous observa-

tions, and indicates, further, the existence of a third modification of nickel stable above 700°. This indication is confirmed by the change of the metal at high temperatures into a brittle form with a coarsely crystalline structure. The first transformation, at 363°, is accompanied by the development of about 3·11 cals. per gm.-atom.

Antimony was investigated at temperatures ranging from 200 to 680°, and within these limits the heat of cooling curve is quite continuous. This metal melts at 630°, and the latent heat is 4·85 cals. per gm.-atom. T. H. P.

1754. *Electrical Conductivity of Alloys of Copper and Zinc.* **N. A. Puschin** and **V. N. Rjashski.** (Russian Physico-Chem. Soc., Journ. 44. pp. 1905–1918, 1912.)—Investigation of the electrical resistance and of its temperature-coefficient for alloys of copper and zinc gives results in general agreement with Shepherd's conclusions based on the melting-point diagram and on the microstructure [Abstract No. 2774 (1904)]. The system forms (1) the solid solutions : α, 0–36 atom. % ; γ, 59–67 atom. % ; ε, 80–85·7 atom. % ; and η, 91–100 atom. % of zinc ; (2) the mixed crystals : $\alpha + \beta$, 36–50 ; $\beta + \gamma$, 50–59 ; $\gamma + \varepsilon$, 67–80 ; and $\varepsilon + \eta$, 85·7–91 atom. % of zinc. The existence of the solid solution, β, within narrow limits is regarded as a sign of the existence of the definite compound ZnCu, which is slightly dissociated at the ordinary temperature. The results also indicate the probable existence of the two compounds Zn_3Cu and Zn_6Cu [compare also Norsa, Abstract No. 1575 (1912)]. T. H. P.

1755. *Iron-Titanium Alloys.* **J. Lamort.** (Ferrum, 11. pp. 225–234, May 8, 1914.)—The equilibrium diagram of these alloys has been studied by the methods of thermal analysis. Alloys containing up to 24 % Ti were prepared by melting ferro-titanium with mild steel in a Kryptol furnace. The liquidus consists of two branches meeting in a eutectic point at 1300° C. and a composition of about 13 % Ti. Iron retains about 6 % Ti in solid solution. Microscopic analysis confirms the results of the thermal study, and also indicates the existence of a compound Fe_3Ti. Study of the magnetic properties showed that the temperature of the magnetic change is lowered by the addition of Ti. The curve showing the relationship between temperature of magnetic change and the Ti-content is practically a straight line running from 0 % Ti and about 787° C. to 21 % Ti and 690° C. The iron-titanium alloys are possessed of higher remanence values than iron itself. The Brinell hardness rises rapidly with the Ti-content, a 21·5 % Ti alloy having a hardness of about 500. Chemical and microscopical tests were also made on ferro-titaniums both with and without carbon. The presence of both nitride and cyano-nitride can readily be recognised under the microscope. The effect of additions of titanium to iron and steel most likely depends on whether the Ti exists in the alloy in the metallic state or in the form of nitride. This probably accounts for the variations in the results obtained by different workers in this field. F. C. A. H. L.

1756. *Iron-Zinc Alloys.* **F. Taboury.** (Comptes Rendus, 159. pp. 241–243, July 20, 1914.)—In galvanising vats, in which the zinc remains for some months at a temperature just above its melting-point, crystals are deposited which are identical in composition with the mixed crystals containing 7·3 % of iron observed by Vegesack [see Abstract No. 739 (1907) ; see also Vigoroux, Ducelliez, and Bourbon, Abstract No. 1465 (1912)]. T. H. P.

1757. *Contribution to the Theory of Hardening.* **A. McCance.** (Iron and Steel Inst., Journ. 89. pp. 192–244; Discussion and Correspondence, pp. 245–265, 1914. Engineering, 97. pp. 823–827, June 12, and pp. 854–856, June 19, 1914.)—Experiments have been made to determine the variations in the hardness, electrical resistance, magnetic properties, density and sonority of steels of different carbon-content with the quenching temperature. Little variation occurs in the hardness until above Ac1, when the greater proportion of the increase takes place within an interval of 20–30° C. In hypoeutectoid steels the max. hardness is obtained when the quenching temperature is above Ac3, but in hypereutectoid steels it is only necessary to heat slightly above the cementite change-point; higher temperatures resulting in the formation of austenite which softens the material. In all steels with above 0·7 % C the max. hardness obtainable was constant, indicating that there is a max. amount of hardening which the iron itself can stand. Steels containing over 0·7 % C, when quenched from 840° C. all show practically the same hardness, while there is a great difference in the amounts of non-magnetic material present, the latter increasing with the presence of austenite. The cooling curve of a round bar during quenching closely follows the theoretical curve calculated on the assumption that the surface of the bar is at 100° C. after immersion, and that the cooling takes place according to the mathematical theory of conduction for this condition. When the temperature of the quenching water is below 20° the hardness values are uniformly high, but above 60° C. the values are low, while between these limits there is an unstable area in which the values show considerable variation, possibly because of the steam not being able to escape so readily. There are only two allotropic modifications of iron: α and γ; β iron being merely α iron which has lost its ferromagnetism owing to thermal causes. The thermal disturbances at A2 are due to sudden changes in the specific heat which has recently been shown to accompany change in magnetic intensity. The author holds the definition of allotropy to be at fault, and considers that only a change in crystalline symmetry is to be defined as an allotropic change. During quenching two changes go on in the steel—a slow change in which the carbon is deposited from solution and a rapid conversion of the γ into α iron. The amount of carbon retained in solution therefore is proportional to the rate of cooling through Ar1, but no practical rate of cooling is sufficiently rapid even appreciably to retard the allotropic change. Experiments showed that although the rate of quenching did not affect the hardness after all the carbon had been retained in solution, it did have an appreciable effect on the rate of tempering, owing to the higher amount of austenite retained in solution. The retention of carbon in solution retains part of the iron in the γ condition, but the major portion is still in the α condition. Since at the temperature of quenching the crystalline grains had the symmetry of γ iron, the γ iron will form an internal network in the original grains. The rest of the iron will be transformed to crystal units of α symmetry, but lack of time, internal friction, and the γ network prevent their arrangement into homogeneously orientated α crystals. The α iron will therefore be in a condition of interstrain, resulting in great hardness. Cracks in hardened steel may be caused either by stresses set up by irregular heating or by stresses set up by irregular cooling. Both causes produce definite modes of cracking, the first cause producing radial cracks in round bars and cracks in the centre of the sides of square bars. The second cause produces circles concentric with the surface in round bars, and rectangular hyperbolæ whose origins are the four corners of the square, in square bars. F. C. A. H. L.

1758. *The Hardening of Metals with Special Reference to Iron and its Alloys.* **C. A. Edwards** and **H. C. H. Carpenter.** (Iron and Steel Inst., Journ. 89. pp. 138–177 ; Discussion and Correspondence, pp. 178–191, 1914. Engineering, 97. pp. 885–891, June 26, 1914.)—The authors discuss the formation of twin crystals, the amorphous theory, and the theories of hardening carbon steels, at some length. During annealing, the softening of the mass is brought about by the gradual removal of the hard amorphous material existing as an envelope round the crystals. The growth of the crystals is probably brought about owing to the unstable nature of the amorphous material which tends to crystallise, and forms the medium whereby the material of one grain is transposed to the next. Photomicrographs are reproduced which indicate that carbon steels show a tendency to form twin crystals when quenched from above $Ar3$. The type of twinning is somewhat different from that produced by annealing after deformation. In the latter case more than two twins are seldom formed in one grain, while in the former case the twins are exceedingly numerous, and frequently appear to intersect each other. At the surfaces of slip on which twinning occurs amorphous layers are formed, and the authors consider that it is to the presence of this amorphous material that quenched steels owe their ultimate hardness. In the case of austenitic steels the presence of the special elements gives rise to the formation of compounds of high molecular weight, which exert a greater osmotic pressure and lower the temperature at which the carbon is rejected from the solution. At the same time the velocity of the change is decreased to such an extent that quenching is not necessary to preserve the mass in the austenitic condition. No twinning occurs in this case, because the pressure necessary to inhibit the carbide change is already inherent in the mass as osmotic pressure, and no internal crystalline disturbance can take place. Evidence is also given as to the constitutional identity of austenite and martensite, the apparent difference under the microscope being due to twinning. F. C. A. H. L.

1759. *Introduction to the Study of the General Properties of Tool Steels.* **Denis.** (Rev. de Métallurgie, 11. pp. 569–570, June, 1914.)—The multiplicity of tool steels all put to the same use and the differences in the results obtained on the same brands of steel in different works appear to indicate variations in the thermal treatment owing to the neglect of carrying out systematic tests previous to the use of the steel. A certain number of brands of tool steels seem to be preferred by a large number of works but on different grounds. To determine if this preference is based on real grounds the author has made, in the workshops of the French Army and Navy, a systematic study of the properties of tool steels, and has divided his report into three parts: (1) General considerations of the methods of testing tool steels and of the thermal treatments which may be applied to them. (2) Various tests made on the principal brands of tool steel used in industry, with the object of determining the best thermal treatment corresponding to any of their various uses. (3) Conclusions of the tests. Characteristics of the steels studied, from the point of view of their constant use. F. C. A. H. L.

1760. *Tempering and Annealing of Quenched Copper-Tin and Copper-Zinc Alloys.* **A. Portevin.** (Comptes Rendus, 158. pp. 1174–1177, April 27, 1914.) —It has already been shown that on tempering a 10 % Al alloy of copper, the pro-eutectoid constituent separates in such a way that a Widmanstätten structure is produced and that the beginning of tempering is marked by an increase of hardness [Abstract No. 607 (1912)]. It appeared to be of interest

to determine if this behaviour were common to all alloys containing a eutectoid. The increase of hardness on tempering copper-tin alloys has already been observed by Grenet [Abstract No. 403 (1911)].

An alloy containing 80·11 % Cu, after quenching from 700° C. consists of the α and β constituents. On tempering at temperatures gradually increasing from 300° to 600° C. fine needles of the δ constituent appear in the region previously occupied by β. The orientation of these needles (Widmanstätten structure) persists even after completety annealing the alloy. Experiments have also been carried out on a pure brass containing 57·91 % Cu, quenched from 825° and tempered at temperatures gradually increasing from 400° to 800° C. The quenched alloy had a hardness of 96, while after tempering at 400° C. the value had increased to 106. Here again, tempering produces a Widmanstätten structure at low temperatures, but as the temperature rises α separates out in thin plates between the original β grains. At 800° C. the Widmanstätten structure is destroyed owing to the coalescence. Similar results were obtained with an alloy containing 25 % Zn and 5 % Al. F. C. A. H. L.

1761. *A New Reagent for Etching Mild Steel.* **W. Rosenhain** and **J. L. Haughton.** (Iron and Steel Inst., Journ. 89. pp. 515–524; Correspondence, pp. 525–526, 1914. Engineering, 97. pp. 783–785, June 5, 1914.)—A brief account of this reagent has already been given in Abstract No. 1004 (1914). Satisfactory results are only obtained when the composition of the reagent conforms with considerable exactitude to the following formula:—Ferric chloride 30 gm., conc. Hydrochloric acid 100 c.cm., Cupric chloride 1 gm., Stannous chloride 0·5 gm., Water 1 litre. In pure carbon-steels the resulting pattern is the reverse of that produced by picric acid, but the most important property of the new reagent lies in the fact that it reveals in an unmistakable manner the distribution of phosphorus in mild steels, yielding results which are comparable with those obtained by heat-tinting. The cause of the pattern is due to the deposition of very thin films of copper. In unhardened steels ferrite is coloured black, while in hardened steels martensite is developed in a remarkably clear manner. In commercial steels patterns identical with those obtained by heat-tinting are obtained. The new reagent is extremely sensitive to the presence of phosphorus, the ferrite containing the least amount of phosphorus in solution being darkened first. It is therefore much more sensitive than picric acid in revealing the presence of ghosts. It appears that the width and distribution of the phosphorus banding depends upon the size and arrangement of the crystals in the original ingot. There is always considerable darkening round the enclosures of slag and sulphides in steel, which appears to indicate that there is a concentration of dissolved impurities in the immediate vicinity of such enclosures. F. C. A. H. L.

1762. *Application of the Theory of Allotropy to Electromotive Equilibria. II.* **A. Smits** and **A. H. W. Aten.** (Konink. Akad. Wetensch. Amsterdam, Proc. 23. pp. 37–54, July 3, 1914.)—It has been previously shown [see Abstract No. 1024 (1914)], by application of the theory of allotropy to the electromotive equilibrium between metal and electrolyte, that a metal exhibiting the phenomenon of allotropy and therefore composed of molecules of different kinds will, when immersed in an electrolyte, emit different ions, possibly of equal size but varying in structure and perhaps in electrical charge. The disturbance of the internal equilibrium between a metal and its solution by electrolytic dissolution of the metal, being attended by a diminution of the more active molecules, will bring about a diminution of the chemical activity,

whereas kathodic disturbance exerts the opposite influence. For very small current densities the internal equilibrium should generally be able to maintain itself, the p.d. with respect to an auxiliary electrode being zero when the metal is either anode or kathode. With increasing current density the metal will become superficially further and further removed from the state of internal equilibrium and the p.d. with respect to the auxiliary electrode will greatly increase. But as this change proceeds and the surface of the metal becomes increasingly metastable, the velocity of the reaction tending to destroy the metastability would increase owing to the change of concentration in the homogeneous phase. Investigations have been made with a number of different metals immersed in solutions of the corresponding salts, the anodic and kathodic polarisation p.d.'s being measured. The internal equilibrium is established rapidly with Ag, Cu, and Pb, and very slowly with Ni, Cd occupying an intermediate position. With Bi, Fe, and Al, catalytic influences are apparently exercised. T. H. P.

1763. *Allotropy of Cadmium.* II. and III. **E. Cohen** and **W. D. Helderman.** (Konink. Akad. Wetensch. Amsterdam, Proc. 23. pp. 54–58, and pp. 122–131, July 3, 1914.)—Further dilatometric investigations [see Abstract No. 772 (1914)], described in Part II, show that the supposed transition temperature, 64·9°, varies with the thermal treatment to which the cadmium has been previously subjected, and it is concluded that there are more than two allotropic forms of cadmium concerned.

Part III contains a description of investigations of Hulett's low-voltage standard cell, cadmium | cadmium sulphate solution | cadmium-amalgam containing 12·5 % of Cd, the Cd electrolyte being deposited electrolytically [see Abstract No. 1932 (1905)]. The e.m.f. of such a cell is 0·0505 volt at 25° when the Cd has just been deposited, but it gradually falls to 0·047 volt. The suggestion that this change in e.m.f. is due to the gradual transformation of unstable γ-cadmium into the stable α-modification is supported by the observation that the diminution in the e.m.f. is considerably increased by lowering the temperature from 25° to 0°. Further, the Cd deposited electrolytically is withdrawn from the 12·5 % (or stronger) amalgam, which was originally a two-phase system, so that it is possible for this layer to become a monophase system, the e.m.f. then increasing if the electrolysis is continued. After the formation of the cell its e.m.f. will then be too high, but Cd will ultimately diffuse to the upper layer, which then resumes its two-phase character, the e.m.f. thus decreasing and finally attaining constancy. It is found, indeed, that replacement of the Cd amalgam, after deposition of the Cd, by 12·5 % amalgam gives a cell with an immediate e.m.f. of 0·0503 volt.

Various phenomena which were described by Hulett and were formerly obscure are explainable in the light of the above results. T. H. P.

1764. *Aluminium-Nickel. The Nickel-plating of Aluminium.* **E. Tassily.** (Rev. de Métallurgie, 11. pp. 670–673, June, 1914.)—None of the large number of the methods which have been patented for nickel-plating aluminium appear to give satisfaction in practice. Generally, the nickel is deposited on an intermediate coat of copper, zinc, or iron, but even then the adherence leaves much to be desired. A method recently patented by Carnac permits the direct deposition of an adherent coating of nickel which can be polished, will stand hammering and heating, and, in fact, the result behaves so much like

an alloy that the author has been led to call it Aluminium-Nickel. The method consists in passing the metal through a bath of boiling potash, brushing with milk of lime, soaking for some minutes in a 0·2 % potassium cyanide solution, and finally treating in a bath of 500 gm. HCl, 500 gm. water, and 1 gm. of iron until the Al assumes a mottled metallic appearance. After each operation the metal is well washed in water. Nickeling is carried out in the ordinary way in a bath containing 50 gm. nickel chloride, 20 gm. boric acid, and 1000 c.cm. of water, using a current at 2·5 volts and a density of 1 amp./dm.^{2}. The success of the process appears to depend on the thorough cleaning and the fact that a thin layer of iron is deposited on the Al from the ferruginous bath. That there is a layer of iron on the metal is proved by the fact that on testing by means of the magnetic balance the susceptibility of metal which has been through this bath is 14 times as great as that of the metal which has simply been boiled in potash. Microscopic examination of the surface reveals the presence of small cells in which the Ni is deposited during electrolysis, the process being assisted by the formation of numerous small couples. The resulting product resists the action of moist air, hot and cold acids and alkalies, hot concentrated salt solutions, alcohol, and does not permit the sweating of petrol. Compared with pure Al the tensile strength is increased, the coefficient of expansion decreased, while the density is only slightly increased. It can be applied in railway construction, shipping, the manufacture of instruments, cooking utensils, and so on. F. C. A. H. L.

1765. *Polarisation Single Potentials.* **C. N. Hitchcock.** (Amer. Electrochem. Soc., Trans. 25. pp. 415–440, 1914.)—The author has investigated the potential at anode and kathode in the case of the electrolysis of sulphuric acid solutions (generally a normal solution) at voltages below the normal decomposition point. The electrodes were of Pt and of varying sizes. It was found that decomposition of water takes place at any voltage, provided the electrodes are of the proper size. The oxygen normally present in laboratory reagents is sufficient to produce marked depolarisation at the kathode. The single potential of each electrode so depends on that of the other that any change in one, due to disturbing influences, is counteracted by such a change in the other that, below the decomposition point, the sum of the separate electrode polarisations equals the total polarisation, which, at the same time, is very nearly equal to the impressed e.m.f. Any desired current may be passed through an aqueous solution of sulphuric or hydrochloric acid without causing evolution of gas, provided the electrodes are made large enough. The evolution of gas at the electrodes depends on the total current density minus that part of the current density neutralised by the action of depolarising agents. T. S. P.

1766. *Electrolytic Deposition of Brass on a Rotating Kathode.* **C. W. Bennett** and **A. W. Davison.** (Amer. Electrochem. Soc., Trans. 25. pp. 347–366; Discussion, pp. 366–367, 1914. Journ. Phys. Chem. 18. pp. 488–509, June, 1914.)—The electrolytic deposition of brass from mixed solutions of the cyanides of zinc and copper has hitherto yielded unsatisfactory results, and, consequently, the authors have made a series of experiments with other solutions of salts of these metals, using rotating kathodes. Preliminary measurements were made of the voltages required to deposit copper and zinc from a number of different salt solutions, the voltages being measured against an oxygen electrode. Those solutions giving similar curves

were then studied with a view to obtaining a good deposit of brass, but in no case, save that of the mixed cyanides, could such a deposit be obtained. Investigation of the reasons for this showed that the deposition of brass from cyanide solutions depends probably on two factors : (1) the tendency of the potentials of copper and zinc to become the same in the cyanide solution, and (2) the increase in the potential of the more noble metal, by impoverishment. The latter factor is practically eliminated by using the rapidly rotating kathode. A *satisfactory* brass has not been deposited from the cyanide solution on the rotating kathode ; the alloy obtained is brittle, the brittleness being probably due to occluded impurities which arise from the cyanide and cannot therefore be removed. The metal ratio of copper to zinc in solutions for the deposition of a brass varies, not only with variations of free cyanide, but also with the rate of rotation of the kathode. [See Abstract No. 1294 (1912).] T. S. P.

1767. *Electro-deposition of Cadmium.* **F. C. Mathers** and **H. M. Marble.** (Amer. Electrochem. Soc., Trans. 25. pp. 297–318, 1914.)—A review of the work which has been published on the electro-deposition of cadmium from (*a*) solutions of cadmium salts of inorganic acids (sulphuric, nitric, halide, hydrofluosilicic, hydrocyanic and phosphoric acids), (*b*) ammoniacal solutions, (*c*) solutions of cadmium salts of organic acids (oxalic, formic, acetic, lactic, succinic, and tartaric acids). There is also a section on commercial plating and refining. T. S. P.

1768. *Effect of Addition Agents in the Electro-deposition of Iron.* **O. P. Watts** and **M. H. Li.** (Amer. Electrochem. Soc., Trans. 25. pp. 529–536, 1914.)—The electrolyte chosen as a basis for the addition of various substances consisted of 150 gm. of crystallised ferrous sulphate and 75 gm. of ferrous chloride ($FeCl_2, 4H_2O$) per litre, and had a specific gravity of 1·125 at 20° C. Ammonium sulphate (120 gm. per litre) was found to give good results as an addition agent, the sulphates of sodium, magnesium, and aluminium not being satisfactory. Using the solution containing ammonium sulphate, the effect of a large number (48) of organic addition agents was tried ; of these, only ammonium oxalate and hexamethylene tetramine improved the remarkably smooth and satisfactory deposit given by the original electrolyte. Solutions of ferrous ammonium fluosilicate or fluoborate are not satisfactory electrolytes. T. S. P.

1769. *Electrolytic Deposition of Zinc.* **J. W. Richards.** (Amer. Electrochem. Soc., Trans. 25. pp. 281–288 ; Discussion, pp. 288–290, 1914.)—An account is given of results obtained : I. In the refining of impure zinc when (*a*) precious metals are absent, (*b*) the anodes contain precious metals ; II. In the direct extraction of zinc from its compounds using (*a*) soluble anodes containing zinc compounds, (*b*) soluble anodes containing no zinc, (*c*) insoluble anodes, but using the electrochemical reaction at the anode, (*d*) insoluble anodes and not utilising the electrochemical reaction at the anode. T. S. P.